

# NORTON'S STAR ATLAS

AND TELESCOPIC HANDBOOK



7000 STARS, CLUSTERS, NEBULÆ, &c.  
FOR EPOCH 1920.

Circular map, 1<sup>st</sup> edition



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# A S T R A T L A S

## AND TELESCOPIC HANDBOOK

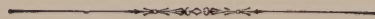
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for Small Telescopes; Notes on Planets,  
Star Nomenclature, &c.*

BY

ARTHUR P. NORTON, B.A.



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## PREFATORY NOTE.

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THIS Atlas is primarily intended for the use of those amateur telescopists whose instruments are mounted either on alt-azimuth stands or as equatorials without graduated circles.

In order to make proper use of a set of star maps, however, it is necessary to be able to recognise at least the more important constellations and their relative positions. It is also necessary to have a proper conception of their apparent daily motions. There is a very useful little book, "An Easy Guide to the Constellations," by the Rev. James Gall (Gall & Inglis), which could be used by the beginner with great advantage as an introduction to the present work.

Short popular explanations of various astronomical terms met with in almanacs and current astronomical literature are given for the benefit of the beginner, and notes on the moon and planets, also selected lists of interesting objects, for the convenience of the occasional observer: but the maps are rather intended to be used as a companion to Webb's invaluable "Celestial Objects for Common Telescopes," and Smyth's admirable "Cycle of Celestial Objects." Practically all the objects contained in the latest editions of these two works, down to and including stars of the seventh magnitude, are shown in the following maps. Several fainter objects of particular interest are added.

The "Uranométrie Générale" of Houzeau, and certain of the catalogues of the Greenwich and Cape Observatories, have also been used in the construction of these maps, so that probably few stars visible to the naked eye have been omitted. Houzeau's work contains the places of 5719 naked-eye stars. In the nomenclature adopted by him, Houzeau has not been followed, nor always in his estimates of star magnitudes. The Revised Harvard Photometry has also been consulted.

Altogether the charts indicate the positions of upwards of 6,500 stars and 600 nebulae, for the epoch 1920.

Owing to the plan and arrangement of the maps, a view of about one-fifth of the entire heavens can be seen on one folio. For this reason, and also on account of the large overlap of the maps, no constellation is inconveniently broken up. The distortion is slight, considering the large area of the heavens represented on each chart.

It has been thought inadvisable to insert letters near the stars in order to denote their duplicity, &c. (except "V" for variable and "R" for red), as such particulars can be more satisfactorily obtained from the lists which must necessarily be used in conjunction with the Atlas: all lettering is made faint so as not to confuse the star groups.

The lines marking the hours of Right Ascension and every tenth degree of Declination are shown in the maps: intermediate distances may be estimated by means of the marginal divisions which mark intervals of five minutes in Right Ascension, and degrees of Declination.

Very great pains have been taken to make the maps correct; but, where so many objects have been charted, one cannot feel confident that no mistake has been made. The writer will be grateful to anyone who, having detected an error, will kindly communicate with him. [*1st Edition, issued 1910*].

### NOTE TO THE SECOND EDITION.

War conditions have necessitated the omission of matter that I should have liked to include, nevertheless a large number of paragraphs and additional notes have been added to the original text of the first edition of this Atlas in order to make it of fuller use to the amateur student of astronomy. An Index for use with the sketch map of the moon, and some brief notes on lunar formations, have been added.

The star maps remain as before, except for a few necessary alterations, but, since they are drawn for the epoch 1920, (the same year as that adopted in the new edition of Webb's Celestial Objects) they will be of use for many years to come.

I wish to record my gratitude and indebtedness to Mr. J. Gall Inglis, the Editor of the new edition of the 'Easy Guide' above mentioned, who originally prepared the draft of pages 3 to 12, and has since collaborated with me in the production of the notes and tables now added.

M. Felix de Roy has kindly furnished me with several valuable suggestions and notes. I take this opportunity of thanking many correspondents for their kind reception of this work.

ARTHUR P. NORTON.

BRANDON PARVA,

WYMONDHAM, NORFOLK.

November, 1918.

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# A STAR ATLAS

FOR SMALL TELESCOPES.

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## I.—NOTES ON STAR NOMENCLATURE, &c.

**The Constellations.**—The origin of most of the constellation names is lost in antiquity. COMA BERENICES was added to the old list (though not definitely fixed till the time of Tycho Brahé), early in our Era; but no further addition was made till the seventeenth century, when Bayer, Hevelius, and other astronomers, formed many constellations in the hitherto uncharted regions of the southern heavens, and marked off portions of some of the large or ill-defined ancient constellations into new constellations. Many of these latter, however, were never generally recognised, and have been dropped altogether, or had their names abbreviated into more convenient forms. Since the middle of the eighteenth century, when Lacaille added thirteen additional names in the southern hemisphere, and subdivided the unwieldy ARGO into the more convenient CARINA, MALUS, PUPPIS, and VELA, no new constellations have been recognised. (See list of constellations at end of book).

**Star Nomenclature.**—The Star Names given in the list on page 25 have for the most part been handed down from classical or early mediæval times, but only a few of them are now in common use, it having been found more convenient to adopt the plan introduced by Bayer in 1603, viz.—the designation of the bright stars in each constellation by the ordinary letters of the Greek Alphabet,  $\alpha$ ,  $\beta$ ,  $\gamma$ , &c. When there were more stars than Greek letters, Roman letters, both ordinary and capital, have also been employed. As the Roman capital letters, however, were not generally used except in the constellations of the far south, the convenient plan has recently been introduced of denoting the principal *variable* stars in each constellation by the Roman capital letters near the end of the alphabet—R, S, T, U, V, &c., thus affording a ready index to their peculiarity. After Z is reached, the letters are duplicated thus—RR, RS, &c. (See also page 9).

The fainter stars are most conveniently designated by their numbers in some star catalogue. By universal consent, the numbers of Flamsteed's British Catalogue (published 1725) are adopted for stars to which no Greek letter has been assigned, while for stars not appearing in that catalogue, the numbers of some other catalogue are utilised. For convenience of reference, the more important star catalogues are designated by recognised contractions: thus, "B.A.C. 2130" is at once known by astronomers to denote the star numbered 2130 in the British Association Star Catalogue, published in 1845. A list of some of the best-known catalogues, and their contractions, is given p. 20. In most star catalogues a number is assigned to each star included in them, whether it has a Greek or other letter, or not. Thus, *Vega* is  $\alpha$  LYRÆ, 3 LYRÆ (Flamsteed's number), and Groombridge 2616, the latter catalogue being arranged in order of Right Ascension, no notice being taken of the constellations.

The usual method of denoting any lettered or numbered star in a constellation is to give the letter, or number, followed by the genitive case of the Latin name of the constellation. Thus  $\alpha$  of CANES VENATICI is described as  $\alpha$  CANUM VENATICORUM. A list of these genitives is given in the list of constellations on the last page, facing the cover.

Flamsteed arranged his stars by constellations, and numbered them according to their order in Right Ascension—a convenient form for reference, as the stars follow a regular sequence. Occasionally, however, stars numbered in order of Right Ascension, in course of time become displaced from this order, owing to the precession of the Equinoxes (or "precession," as it is termed for short). This happens if their Right Ascensions are nearly the same, and if they are widely different in Declination. Another point that may puzzle beginners is that in celestial globes the stars are reversed as regards left and right; this is because a globe necessarily represents the star sphere as seen from the *outside*, while we view the stars from the *inside* of the star sphere.

**Constellation Boundaries.**—These have never been definitely agreed upon, so that occasionally Flamsteed and others numbered stars in one constellation which in other catalogues or charts are included in a neighbouring constellation. Thus 24 and 26 CAMELOPARDI of Flamsteed are included in PERSEUS in the present work. Occasionally, also, in assigning Greek letters, stars were included by mistake in *two* constellations. For example,  $\beta$  TAURI and  $\gamma$  AURIGÆ are one and the same star. The same thing occasionally happens in star catalogues: Flamsteed, for instance, is known to have duplicated half a dozen stars.

## II. NOTES ON ASTRONOMICAL TERMS.

**The Star Sphere** is an expression used for convenience in speaking of the heavenly bodies and their positions with respect to one another. The name is derived from the appearance presented by the heavens as seen from the earth, the earth being apparently at the centre of a vast hollow sphere, which makes a complete revolution every day, and to the inside surface of which the stars seem fixed—for they do not sensibly change their place relatively to one another, in spite of their daily revolution, and hence are called ‘fixed’ stars. Of course, only half of the star sphere can be seen, at the same moment, from any place on the earth—or slightly more, as refraction gives  $\frac{1}{2}^\circ$  additional.

The pivots, as it were, of this sphere—the *Celestial Poles*—are directly overhead at the terrestrial poles; and its equator—the *Celestial Equator*, or *Equinoctial*, half-way between the poles—is directly overhead at the terrestrial equator. It is therefore easy to indicate the positions of the stars by saying they are so many degrees north or south of the celestial equator (called the stars’ ‘Declination’), and so many degrees east of some meridian. The latter distance, however, is for convenience usually expressed in hours and minutes of *time* instead of degrees, as explained below, and is termed ‘Right Ascension’; but degrees of R.A. are used by observers of meteors, and for some other purposes.

**Right Ascension.**—The Right Ascension of a star (contracted “R.A.”) corresponds to the longitude of a place on the earth’s surface. The starting point is known as “The First Point of Aries,” a point in the sky situated on the celestial equator, nearly as far *below*  $\gamma$  PEGASI as  $\alpha$  ANDROMEDÆ is *above* it—stars forming one side of what is known as “The Great Square of Pegasus”—or a little below the small star  $\omega$  of PISCES.

As the heavens circle completely round the earth once each day, it is easy to note how many hours, minutes, and seconds elapse between the time at which this point ‘culminates’ (*i.e.* attains its highest altitude above the horizon, see p. 5) and the time of culmination of any desired star. This interval is called the star’s Right Ascension. Thus every star which culminates at the same instant as the “First Point of Aries,” is said to have a Right Ascension of 0 hours, 0 minutes; all that culminate three hours later are said to have a Right Ascension of three hours, and similarly for any other interval, up to twenty-four hours, which is the same as 0 hours, 0 minutes. Strictly speaking, these hours, minutes, and seconds of Right Ascension are respectively very slightly shorter than the hours, minutes, and seconds of ordinary clocks, because the stars make a complete circuit of the earth in 23 hours, 56 minutes, 4 seconds, or in about four minutes less than a mean solar day. Observatories are provided with special clocks, regulated to keep this sidereal time, for reading off the exact instant of culmination, of planets, comets, &c., and thus finding their R. A.

In more scientific language, the First Point of Aries is the point in the sky at which the centre of the Sun crosses the celestial equator at the vernal equinox in March, but yearly it changes its position slightly among the stars, moving back on the Ecliptic  $50\frac{1}{4}''$  of arc per annum (=about 3 seconds of R.A.), or a space equal to the apparent diameter of the Moon in about thirty-nine years. Though it retains its old name, it is no longer in the constellation of ARIES but in that of PISCES. This is why star charts get out of date: the starting point of measurement is not fixed, and both the Declination and Right Ascension lines in the chart after a while no longer represent the actual positions with reasonable accuracy, especially near the Celestial Poles. This backward motion is ‘*precession*.’

**Declination.**—The Declination of a star (contracted “Dec.”) corresponds to terrestrial latitude, and is measured by the number of degrees the star is north or south of the Celestial Equator, which is simply an extension, as it were, of the terrestrial equator as far as the star sphere. As already mentioned, at the terrestrial equator the celestial equator is directly overhead; and similarly at any latitude on the earth’s surface, the stars with the same amount of Declination as the latitude will be directly overhead when culminating. The signs + and – are sometimes used instead of N. and S., to distinguish between North (+) and South Declination (–).

Stars with a *greater* declination than the co-latitude\* of the observer never set, but are always above the horizon, if both observer and star are on the same side of the equator, or never rise if they are on opposite sides of the equator. Thus in latitude  $50^\circ$  north, all stars with declination north greater than  $40^\circ$  never set, and those with declination south greater than  $40^\circ$  never rise above the horizon.

\* The difference of the latitude from  $90^\circ$ .

**North Polar Distance** (contracted 'N.P.D.'), measured from the North Celestial Pole, is sometimes used instead of Declination, as mistakes are apt to arise with "N." and "S". It ranges from  $0^\circ$  at the N. Pole to  $180^\circ$  at the S. Pole.

**Longitude** (which in astronomy does not correspond to terrestrial longitude), must not be confused with Right Ascension, from which it is quite different. Both start from the First Point of Aries, and are measured eastwards, but the former is measured in degrees ( $0^\circ$  to  $360^\circ$ ) along the *Ecliptic*; the latter along the *Celestial Equator*, in hours &c.—1 hour being exactly  $15^\circ$ , and 4 minutes exactly  $1^\circ$ . As the ecliptic lies at an angle to the celestial equator, a movement of  $1^\circ$  in longitude does not exactly correspond to  $1^\circ$  (*i.e.*  $\frac{1}{15}$  hour, or 4 minutes) in Right Ascension, because (a), the direction of measurement is different, and (b), the respective degrees may differ in length on the star sphere—as, for instance, where the 'great circle' degrees of the ecliptic traverse the ever-narrowing R.A. degrees at Dec.  $20^\circ$ .

The term 'longitude' is now chiefly used in connection with the sun, moon, planets, and comets, and is the angle between the First Point of Aries ( $\gamma$ ) and the foot of a perpendicular line drawn from the planet, &c., to the ecliptic. As ordinarily used, the term means 'geocentric' longitude, *i.e.*, as observed from the centre of the earth, as contrasted with 'heliocentric' longitude. It is more convenient than Right Ascension for describing the circuit of planets round the star sphere, because the principal planets, on the whole, follow the course of the ecliptic, not the celestial equator.

*Heliocentric Longitude* is the longitude of a planet or comet as seen from the sun's centre, instead of the earth's. It is measured eastwards in degrees along the ecliptic from the First Point of Aries, and being independent of the earth's orbital motion, &c., is used instead of geocentric longitude in many calculations.

**Latitude**, now chiefly employed for planets and comets, is used, like celestial longitude, in a different sense from what it is in geography. Terrestrial latitude is measured from the equator; but celestial latitude from the ecliptic, in degrees north or south, on an arc at right angles to the ecliptic. Latitude is 'geocentric' (ordinary latitude), or 'heliocentric,' according as the measurement is supposed to be taken from the earth's centre, or from the sun's centre, respectively.

**The Ecliptic**, shown on star charts, indicates the path traced out by the centre of the Sun as it travels among the stars in its (apparent) annual circuit of the heavens. That is to say, if we could see the Sun and the stars behind it at the same moment, day by day, we should find the Sun exactly following the line shown on the charts.

*The Poles of the Ecliptic* are situated at  $90^\circ$  of celestial latitude, and may be regarded as fixed points on the star sphere. The position of the northern pole of the ecliptic (R.A. 18h. 0m., Dec.  $66^\circ 33' \text{N.}$ ) is very nearly marked by the nebula H.IV. 37 in Map I.: the southern ecliptic pole is R.A. 6h. 0m., Dec.  $66^\circ 33' \text{S.}$

*The Obliquity of the Ecliptic* is the angle which the plane of the ecliptic makes with the plane of the equinoctial, or celestial equator; it is the same as the inclination of the earth's equator to the ecliptic, and amounts to  $23^\circ 27'$  (Jan. 1, 1920). It decreases by nearly half a second annually, and varies slightly owing to nutation.

**Colures.**—These will be found marked on celestial globes, &c. The *Equinoctial Colure* is the great circle passing through the celestial poles and the First Point of Aries (or "equinox" as it is otherwise called), and is the same as the circle of 0 hrs. and 12 hrs. of Right Ascension. The *Solstitial Colure* is the great circle of R.A. 6 hrs. and 18 hrs.

**Meridian, Zenith, Nadir, Prime Vertical.** The *meridian* is the great circle which passes through the celestial poles and the north and south points of the observer: the *zenith* and *nadir*, the points in the sky directly over his head, and below his feet: the *prime vertical*, the great circle passing through the zenith and his east and west points.

**Altitude, Azimuth.** The *altitude* of a heavenly body is its vertical angular distance above the horizon; its *azimuth*, the horizontal angular distance between the observer's meridian and the foot of a perpendicular drawn from the object to the horizon. In the Northern hemisphere, azimuth is usually measured from south ( $0^\circ$ ) westwards.

**The Zodiac** is the belt of the sky extending 8 degrees on each side of the ecliptic, in which the moon and principal planets are always to be found. It is divided into twelve 'Signs,' each  $30^\circ$  in length, but owing to precession, the signs of the Zodiac do not now coincide with the *constellations* of the same name. They are denoted as on page 21.

**Culmination, Transit, &c.**—A star 'culminates' when it reaches its highest point above the observer's horizon. In the Northern hemisphere this invariably takes place when the star is due south of the Pole; in the Southern, when it is due north. 'Meridian passage,' 'on the meridian,' 'returns to the meridian,' 'transit,' 'upper transit,' and (in northern latitudes) 'southing,' have the same meaning as culmination. 'Transit,' however, has also a special meaning, see p. 6.

*Lower culmination or transit*, of 'circumpolar' stars which never set, indicates their position 12 hours after ordinary culmination, when *nearest* the horizon, at the opposite side of the celestial pole. *Moon-culminating stars*, used in navigation, are those that culminate about the same time as the moon, and do not differ much in Declination.

**Transit**, 'upper transit,' 'lower transit,' are ordinarily used in the sense of meridian passage (see 'culmination,' page 5), but the term is also applied, in a special sense, to the crossing of *Mercury* or *Venus* as black circular spots in front of the sun's bright disc; or of a satellite, or its shadow (see p.10), across the disc of its primary planet. The *ingress* is the entrance on the disc, and the *egress* the departure from the disc.

**Motions of Planets and Comets.**—A planet, &c., is in *perihelion* ( $\pi$ ) when at its nearest distance to the sun,\* and in *aphelion* when it has reached its greatest distance from it. *Perigee* is the point of the moon's orbit which is nearest the earth, and *apogee* that which is most distant from it; but the terms are sometimes applied to the planets in the same sense. Planets, &c., are in *conjunction* ( $\odot$ ) with the sun, moon, or another planet, when their longitudes are the same—*Mercury* or *Venus* being in *superior conjunction* with the sun when the conjunction occurs while they are on the far side of the sun from the earth (*i.e.* the sun being between the planet and the earth), or in *inferior conjunction* if they are on the near side of the sun; 'conjunction' more rarely denotes similarity in Right Ascension.

Mars and the planets beyond—*Jupiter*, *Saturn*, &c., are in *opposition* (symbol  $\mathcal{Z}$ ) when their angular distance on the star sphere away from the sun is  $180^\circ$  of longitude (or 12 hrs. R.A.), so that they are on the meridian about midnight, and also nearest the earth; and in *quadrature* ( $\square$ ) when they are  $90^\circ$  of longitude (or 6 hrs. R.A.) from it, thus being on the meridian about 6 a.m. or 6 p.m. Planets are said to be *stationary*, when their seeming movement east or west among the stars is changing to the reverse direction, and *retrograde* when their seeming motion among the stars is westerly instead of easterly, or *direct*. The *elongation* of a planet is its *angular* distance (*i.e.* its distance in degrees) from the sun as seen from the earth; the *greatest elongation* of *Mercury* or *Venus* being at the time when this angular distance is at its maximum. *Recession* means that a comet is moving away from the sun, after perihelion.

When a planet or comet, in its movement among the stars, reaches the ecliptic on the star sphere—that is, in reality, reaches the *plane* of the ecliptic—it is said to be at a *node* of its orbit. If it is passing from the north to the south side of the ecliptic, it is at the *descending node* (symbol  $\mathcal{Z}$ ); if the reverse, at the *ascending node* (symbol  $\mathcal{Z}$ ). The nodes, in fact, are the points of intersection of the planet's orbit with the ecliptic.

**Direct and Retrograde Motion.**—A planet or comet has *direct* motion, when its orbital motion, with respect to the sun, is from west to east; *retrograde*, if from east to west. Similarly satellites, with respect to their primaries.

**Limb, Vertex.**—The *limb* is the edge of the disc of the sun, moon, or of a planet; the *vertex*, the point on its limb furthest above the observer's horizon. Distances from the vertex are counted eastwards in degrees from  $0^\circ$  to  $360^\circ$ .

**Albedo.**—The albedo of a planet, is its light-reflecting capacity per unit of area—actual, not angular area. It varies considerably, for, according to Zöllner, *Mercury* reflects .13, *Venus* .50, *Mars* .27, *Jupiter* .62, *Saturn* .52, *Uranus* .64, *Neptune* .46, and the *Moon* .174, of the light which they respectively receive from the sun. Other estimates of *Venus* are even brighter. The albedo of terrestrial clouds is estimated at about .72.

**Astronomical and Sidereal Time.** Astronomers begin their day at noon instead of midnight, as in civil time, and number the hours I to XXIV: noon is '0 hrs.' or 'XXIV hrs.' Thus noon to 12 p.m. civil time, is the same as 0 hours to XII hours astronomical time, and I a.m. civil time is the same as XIII hours astronomical time, and so on. (This refers to astronomical *solar* time; 'sidereal' time is quite different.) But XII to XXIV hrs. belong to the astronomical day *preceding* that current from midnight to noon, civil time, and are dated accordingly.

*Sidereal time* is the number of sidereal hours, minutes, and seconds, that have elapsed since the preceding meridian passage of the First Point of Aries, each 'hour' being  $\frac{1}{24}$ th of the interval between two successive meridian passages, or about 10 seconds shorter than the mean solar hour. As mentioned on page 4, astronomers have special clocks regulated to this time, which, in fact, show the hour of Right Ascension on the meridian, at any given moment. *Twilight* is reckoned as ending when the sun is  $18^\circ$  below the horizon: it is shortest about the time of the equinoxes.

**Equation of Time.** This is the amount which it is necessary to add to or subtract from the apparent time, as shown by a sun-dial or other solar observation, in order to obtain the 'mean time' as shown by an accurate clock. The correction is required because the intervals between two successive southings, or transits, of the sun are not equal. On or about April 15, June 14, Sept. 1 and Dec. 24, the sun and clock agree; on all other dates the clock is either before or after the sun, from a few seconds to 16 minutes. The amount for each day is given in almanacs.

**Hour Angle.** The 'hour angle' of a star, &c., may be defined as the difference between its Right Ascension and the hour of R. A. on the meridian at the time of an observation. In more scientific language, it is the angle which the Declination circle passing through a star, &c., makes with the meridian, usually expressed in hrs. &c., of sidereal time.

\* Or principal star, when the term is used in connection with the smaller star in a binary system.

**Apparent**, as 'apparent R.A., or Longitude,' 'apparent place, or position,' 'apparent obliquity,' 'apparent noon, or time,' &c., is a term used in almanacs to distinguish *observed* readings (*i.e.*, those actually read off on the instruments at that particular moment) from *true* readings, which have to be 'reduced' from these observations by correcting them for the effects of nutation, or aberration, or equation of time, &c. Astronomically, 'apparent' is also sometimes used in the sense of 'as viewed from the earth'—as in 'apparent diameter,' 'apparent motion, displacement,' &c.

**Refraction**.—All observations have to be corrected for atmospheric refraction, which raises the apparent position of a heavenly body higher than its true one, by about  $\frac{1}{2}^{\circ}$  at the horizon, decreasing to  $0^{\circ}$  at the zenith: see Table, p. 20.

**Epoch** is used to indicate the date for which astronomical catalogues, charts, &c., have been calculated, so as to facilitate identifications at future dates, in spite of precessional changes in R.A., &c., explained on p. 4. The usual epoch date is noon of Jan. 1st of the year mentioned. Thus the epoch of this atlas is Jan. 1, 1920, and the star positions are shown *exactly* for that date only, by theory; but for practical purposes the maps will serve for at least another 20 years.

**The Precession of the Equinoxes**, already referred to, is due to a slow wobbling movement of the earth's axis, which causes the celestial poles (which are exactly above the N. and S. poles of the earth) to move in circles round the poles of the Ecliptic, at a distance of nearly  $23\frac{1}{2}^{\circ}$ . This circular movement ( $50\cdot26''$  per annum) is completed in about 25,800 years; it is caused by the attractions of the sun, moon, and, to a very small extent, of the planets, acting on the protuberant portions of the earth at the equator, in combination with the earth's rotation.

**Nutation**.—The path traced on the star sphere by the celestial pole, owing to precession, is not a true circle, but a wavy line slightly varying from the circle. This irregularity is called Nutation, because it is, as it were, a 'nodding' of the celestial poles to and from the poles of the Ecliptic. Though a minute movement (about  $18''$  in  $18\frac{2}{3}$  years), it results in an apparent displacement in the Right Ascensions and Declinations of each of the stars, and has therefore to be allowed for in the accurate determination of a star's place. Nutation is due to the moon being sometimes above and sometimes below the Ecliptic, and so not always pulling in the same direction as the sun.

**Aberration** of light has also to be allowed for, as the velocity of light, combined with that of the earth in its orbit, causes an apparent displacement in the direction of the heavenly bodies, which varies to and fro through the year. At the end of a year, however, a fixed star returns to its original place, so far as the effects of aberration are concerned.

**Parallax** is the difference in direction of an object when viewed from two different standpoints, and is expressed by the No. of seconds, &c., of arc subtended by the line joining the two standpoints, *as seen from the object*. In ordinary or *diurnal* parallax, the two standpoints are the earth's centre and the observer, separated by the radius of the earth's diurnal or *daily* circuit: it is greatest when the object is on the observer's horizon (termed the *horizontal* parallax), and decreases to zero at the zenith, when the object, observer, and earth's centre, are in the same line. Parallax, as ordinarily stated, is the *equatorial* horizontal parallax, *i.e.* as seen at the equator, where the earth's radius is greatest. *Parallax in altitude* is when the object is not on the horizon. The greatest diurnal parallax is that of the moon,  $57'$ .

*Annual parallax*, the angle subtended by the mean radius of the earth's orbit, or *yearly* circuit, as seen from a star, is used for stars, their diurnal parallax being nil. If this is known, the star's distance can be easily calculated, but the difficulty of observing the very minute angles involved makes the results uncertain. Even the nearest known star,  $\alpha$  CENTAURI, has a parallax of only  $0\cdot75''$ , indicating a distance so vast that the mile fails as a unit of measurement.

A unit often used is the *Light-year*, or distance that light, travelling 186,300 miles per second, moves in a year—in round numbers, 6,000,000,000,000 miles:  $\alpha$  CENTAURI is  $4\frac{1}{3}$  light-years distant. Another unit, the *Parsec*, denotes the distance of a star having a parallax of  $1''$ , equivalent to a distance of 19 millions of millions of miles, or 206,265 times the distance of the earth from the sun. It corresponds to about  $3\cdot2$  light-years; a light-year = about  $\cdot31$  parsec.

**Proper Motion**.—When the positions of the so-called fixed stars are compared with what they were a century before—allowance being made for the effects of precession, nutation, and parallax—it is found that while some of the stars, so far as our instruments can determine, remain in the same position on the star sphere as they occupied 100 years previously, others appear to have moved from their places to some extent. The latter are said to have *proper motion*, and as this angular displacement is continuous, though minute, it has to be taken into account in the preparation of accurate star catalogues for any particular epoch. Sometimes the members of large groups of stars are found to have proper motions similar in direction and extent: Proctor termed this phenomenon *star drift*.

The stars with the greatest known annual proper motion are the 6th magnitude star 1830 Groombridge ( $7''$ ) in URSA MAJOR; an 8th magnitude star in the Southern Hemisphere (nearly  $9''$ ); and a 10th magnitude star in OPHIUCHUS, found in 1916 to be moving slightly more than  $10''$ —the greatest annual proper motion yet discovered.

**Star Magnitudes.**—The brightest stars are said to be of the 1st magnitude; those less bright, of the 2nd magnitude; those still less bright, of the 3rd magnitude, and so on. Each magnitude is about  $2\frac{1}{2}$  times as bright as the one below it, a standard 1st magnitude star (*e.g.* *Aldebaran*, *Altair*) being 100 times as bright as a standard 6th magnitude star, about the faintest visible to the naked eye. As, however, several 1st magnitude stars are much brighter than *Aldebaran*, the range of magnitudes is now still further extended, a star of magnitude '0' being about  $2\frac{1}{2}$  times as bright as one of magnitude 1, and one of magnitude *minus* 1, about  $2\frac{1}{2}$  times brighter than one of magnitude 0. Intermediate magnitudes are denoted in tenths; thus magnitude 3.0 is slightly brighter than 3.1, but less bright than 2.9. These 'catalogue' magnitudes are always calculated for the zenith: at lower altitudes atmospheric absorption diminishes the brightness, which has to be allowed for when comparing stars at different altitudes: see Table, page 19. The magnitude of two or more stars, so close as to appear to the naked eye as a single star, is called the *combined magnitude*. The 11th magnitude is about the faintest visible in a three-inch telescope, and the 18th, in the most powerful telescopes yet constructed. For the magnitudes of the brighter stars, sun, &c., see Table on page 24.

The *opposition magnitude* of a superior planet or asteroid, is its brightness when seen in 'opposition' (p. 6)—the time when it is nearest the earth, and therefore brightest; also (theoretically), the only time at which we can see the whole disc illuminated by the sun. As the planet's distance from the earth varies at different oppositions, the magnitude varies also, and the phrase, as ordinarily used, is the *mean opposition magnitude*.

**Star-classification by their spectra.**—Secchi in 1863-67 found that when the light emitted by different stars was analysed by the spectroscope, their spectra fell into four well-marked groups which graded into one another. In 1874, Vogel modified Secchi's scheme by including his third and fourth types as sub-divisions of the same order, and inserting three subordinate classes. Later, Pickering lettered Secchi's original groups, with others, as in the following table, gradations or intermediates being indicated by combinations of the letters with figures denoting tenth parts. Thus B2F (abridged to B2) denotes a spectrum nearly like that of Class B, but estimated to be two-tenths of the way from B to the following Class A. P is used for gaseous nebulae, and Q for Novæ. It is believed that these types, as arranged below, indicate the life-history of the evolution of a star, as such.

**TYPE V.** WOLF-RAYET (O). White Stars: bright lines in their spectra indicate a connection with gaseous nebulae. All in the Milky Way.  $\gamma$  VELORUM.

**TYPE I.** ORION STARS (B). 'Helium Stars.' Very brilliant and hot, of bluish hue. Small proper motions: very distant: binary stars with known orbits absent. Great globes of glowing gas.  $\delta$ ,  $\epsilon$ , and  $\zeta$  ORIONIS,  $\beta$  CRUCIS.

SIRIAN STARS (A). 'Hydrogen Stars.' Very bright and hot, but less so than (B). Most numerous type. Greater proper motions than (B); measurable parallaxes occur, also binaries with known orbits. In two streams moving parallel to the plane of the Milky Way. *Sirius*,  $\alpha$  ANDROMEDÆ,  $\beta$  CARINÆ.

**TYPE II.** CAPELLAN STARS (F). 'Sirian-Solar' type. Much less numerous than (A), but includes majority of known binaries, and of stars with large proper motion, and measurable parallax.  $\gamma$  BÖÖTIS, *Canopus*,  $\alpha$  HYDRI.

SOLAR STARS (G). Hydrogen lines narrower and less intense; many fine, dark lines in spectra. Move more rapidly than preceding types. Not confined to the Galaxy. *Capella*,  $\alpha^1$  CENTAURI,  $\beta$  HYDRI.

ARCTURIAN STARS (K). 'Red-Solar' type. *Arcturus*,  $\alpha$  URSÆ MAJORIS,  $\alpha$  and  $\beta$  INDI.

**TYPE III.** ANTARIAN STARS (M). Spectra like that of the sun, but with broad bands or flutings. Deep red stars, usually variable, as if approaching extinction. Have the most rapid proper motions, in all directions. Stars widely scattered. *Antares*, *Betelgeuse*, *Mira*.

**TYPE IV.** CARBON STARS (N). Peculiar spectra like those of comets and candle-flames, due to carbon compounds.  $\gamma$  CANUM VENATICORUM, 19 PISCUM.

**TYPE VI.** (R). This visually resembles IV, but is photographically different.

**Double Stars** are stars which to the naked eye appear as a single point of light, but when viewed through a telescope are found to be composed of two stars. *Triple stars* have three, *quadruple stars* four, and *multiple stars* many components. Where one of the stars is of a much smaller magnitude than the other, it is often styled a *comes* (plural *comites*) or companion. The most interesting 'doubles,' &c. are indicated in the Notes appended to each star chart.

**Binary Stars** are double stars which have been proved to revolve round a common centre of gravity. *Spectroscopic Binaries* are those discovered to be binary by the displacement of the lines in their spectra, although too close together to be 'resolved,' *i.e.* seen separate, in the telescope. Visible binary stars have periods varying from a few years to many centuries. Sometimes, if the plane of their orbit is in the line of sight from the earth, they approach closer and closer together, and at last appear to the eye as a single point for a considerable period, afterwards opening out.

**Star Clusters** are small groups of stars crowded very closely together: a few, like the *Pleiades* in TAURUS, and the *Præsepe* in CANCER, are visible to the naked eye. In the telescope, clusters are a glorious sight: see Notes, Star Charts.

**Variable Stars** are those which wax and wane in brightness, more or less regularly, and are of many types. Those not otherwise lettered or numbered are designated by the Roman capital letters R, S, T, ... to Z: after Z, the double form RR to RZ, SS to SZ, and so on to ZZ, is used (omitting those like SR, TR, TS, &c.), followed by AA to AQ, BB to BQ, &c., (J omitted). A recent and simple system denotes the 'variables' of each constellation by  $V_{12}$  (= R),  $V_{23}$  (= S),  $V_{34}$  (= ZZ), &c. Another denotes variables by a single letter with index number added: thus RS = S<sup>2</sup> CEPHEI; ZZ = Z<sup>6</sup> CYGNI.

These letters are assigned when the variability is confirmed. Variables and novæ are now provisionally designated by a number, year, and constellation, Nova AQUILÆ 1918 being 7.1918 AQUILÆ, in the 'variable' discoveries of 1918. As leading examples of the more important types and degree of variability the following may be mentioned:—

*Algol* ( $\beta$  PERSEI) is generally of about the 2nd magnitude, but it loses and regains  $\frac{3}{4}$  of its light once in 68.8 hours, the change occupying about 9 hours. It is the chief of the 'eclipse-star' type, so called because its decrease of brightness is due to a partial eclipse by a dark companion. (See almanacs for dates of minima).

$\delta$  CEPHEI varies from 3rd to 5th magnitude in about  $5\frac{1}{2}$  days. Stars of the 'Cepheid' type have an average period of about 7 days, and their increase is more rapid than their decrease of light.

$\beta$  LYRÆ. A 'short period variable,' with a cycle of light-changes completed in 12 days 22 hours, and consisting of two equal maxima with intervening unequal minima.

*Mira* ( $\alpha$  CETI). A 'long period variable,' with a very great change of brightness at fairly regular intervals (average 332 days).

$\eta$  ARGUS has irregular and great variations of brightness with no definite period.

**Novæ**, or New Stars, also called 'Temporary Stars,' are stars which suddenly blaze out where no star—visible to the naked eye at least—has been known before, and then gradually fade away. The older Novæ are designated by the year and constellation in which they appeared, thus, *Nova* SCORPII, 134 B.C.: some have also what may be called a 'popular' name, as *Kepler's Star*, *Tycho's Star*, &c. Modern Novæ are commonly designated by the constellation in which they appear: if more than one appears in a constellation, they are numbered successively *Nova* 1, *Nova* 2, and so on, of that constellation, the older Novæ being disregarded. Thus the great new star of 1918 is *Nova* AQUILÆ 3, as Novæ (telescopic) appeared in AQUILA in 1900 and 1905. Some Novæ have been lettered as variable stars; thus T CORONÆ BOREALIS = *Nova* CORONÆ BOR., 1866. The spectra of Novæ are usually characterised by broad bright, and dark lines, side by side, the significance of which is not yet understood. See Notes on changes in colour, and List, p. 19.

### III. NOTES ON THE PLANETS, STARS, NEBULÆ, &c.

**The Planets** cannot be inserted in star charts as their positions are continually changing, but as the *Nautical* and other almanacs give their R.A. and Declination from day to day, their places among the stars are easily found.

The principal planets are always near the Ecliptic, within the limits of the zodiac, and as they do not twinkle, unless very low down, are readily distinguished from fixed stars. They are denoted by the symbols given on p. 21. Mercury and Venus, nearer the sun than the earth, are called the *inferior planets*; Mars and those beyond, the *superior planets*.

**Mercury** is always so close to the Sun, that, even when most favourably situated, it is only observable for about 2 hours (to the naked eye,  $\frac{1}{2}$  hr.), after sunset or before sunrise, and at a very low altitude, especially in higher latitudes. Mercury is best seen when greatest elongation ( $16^\circ$  to  $29^\circ$ ) is near the time of the equinoxes; it is then better situated for those in the S. hemisphere, as the maximum greatest elongation ( $29^\circ$ ) is attained at aphelion, when S. of the celestial equator. In European latitudes it is most favourably placed in the Spring, as an evening star,\* some days before greatest E. elongation, one in April being best. Observers in the tropics have best conditions. Mercury has phases like the Moon. Average elongation mag., +0.2; maximum, near superior conjunction in perihelion, -1.8: angular diam.,  $4\frac{1}{2}''$  to  $14''$ .

**Venus**, the brightest of the planets, can sometimes be seen in broad daylight. Its dazzling brightness renders observations of the surface-markings very difficult, and for small telescopes its chief interest is that it has phases like the Moon—sometimes discernible even with an opera-glass: examine in the daylight, or as soon as possible after sunset or before sunrise. It appears brightest during the 'crescent' phase—as an evening star about a month *after*, and as a morning star about a month *before* its greatest elongation (maximum  $47^\circ$ ). The angular diameter of its disc varies from  $10''$  to  $65''$ : mag. -4.3. As its brightest, which occurs every 8 years, it is about 12 times brighter than *Sirius*.

**Mars** is usually of little interest in a small telescope, unless at opposition (oppos. diam.  $16''$  to  $30''$ ; minimum diam.  $3\frac{1}{2}''$ ), being then nearest the earth, or from 35 to 62 million miles distant. About every 15 years (from 1924) a 'favourable' opposition occurs, the planet's distance from us being about the minimum: its ruddy disc is then large enough for dark green markings (supposed to be seas) to be seen, and generally a white spot at one or both poles, probably due to snow. The so-called 'canals' are visible only in large telescopes. Mars is 'gibbous,' *i.e.*, not fully illuminated, except in or near opposition; it is most gibbous at quadrature. Mean opposition mag. -2.25, but it sometimes rivals Jupiter.

\* As a morning star, best seen some days *after* W. elongation.

**Jupiter** is a fine object for small telescopes, its 'parallel belt' markings, and elliptical shape being plainly seen : it is slightly gibbous in  $\square$ . The changeable markings rotate in about 9h. 50m. at the equator, usually more slowly near the poles. The 'Great Red Spot,' discovered 1878, was some  $30,000 \times 7000$  miles, and varied some thousands of miles in position. Bright till 1881, by 1892 it had faded to a pale orange, and was ill-defined : though now invisible (1918), a faint bay or hollow in the belt still marks its position. Jupiter's angular diameter is  $28''$  to  $46''$ ; mean opp. magnitude,  $-2.52$ .

Four of Jupiter's satellites, or 'moons,' are visible in a opera-glass, all being about magnitude 6; the others only in giant telescopes. Three of these satellites are eclipsed by Jupiter's shadow once every revolution, but they do not disappear instantaneously, as the motion is slow. Sometimes a satellite 'transits' or passes across the face of the planet, appearing at the beginning or end of the transit as a bright spot on a dark background (the 'limb,' or edge, of the planet's disc being darker than the centre), while at intermediate times it may disappear from view altogether, if the background happens to be similar in brightness and colour, or it may appear as a dark spot. The shadows of the satellites also transit the planet's disc, showing as dark spots, which are apt to be mistaken for the satellites themselves; sometimes both satellite and shadow may be seen transiting at the same time. Occultations, which occur when the satellites pass behind the body of Jupiter, are frequent, but generally of little interest. The configuration of the larger satellites throughout the year is given in almanacs. They are numbered consecutively I, II, III, IV, in order of distance, I being nearest the planet.

**Saturn** is also a magnificent object for a small telescope; faint parallel-belt markings may be discerned, but its special feature is its wonderful 'ring' system, divided into two by a hair-like dark line known as 'Cassini's Division,' just visible in a  $2\frac{1}{2}$  in. refractor when the rings are widely open. A dusky ring, nearest the planet, called the 'Crape or Gauze Ring,' can be seen in a 4 in. telescope. At intervals averaging  $14\frac{3}{4}$  years (from 1920-21), when Saturn is in the signs of Virgo or Pisces, the rings present their edge to the sun or earth, and become invisible for a time; and when the planet is in those of Gemini or Sagittarius, the rings are fully open, and it is about twice as bright as when they are invisible. The rings are designated A, B, and C. A, the outermost, is fainter than B, and both have been seen to be sub-divided in powerful telescopes; C is the dusky Crape Ring. Saturn's angular diameter is  $15''$  to  $20''$ ; mean opp. magnitude,  $-0.93$ .

Saturn's brightest satellite, Titan (mag. 9.4) may be seen with a very small telescope; Rhea, Tethys, Dione, and Iapetus (mags. 10.8, 11.4, 11.5, 11.4, respectively) with a 4 in. instrument, the first sometimes with a 3 in., or even less.

**Uranus** appears as a star of the 6th magnitude to the naked eye. Its disc, having an angular diameter of only  $3\frac{1}{2}''$ , and also its satellites, are only distinguishable in large telescopes.

**Neptune** can be seen with the aid of an opera-glass when its position is found by reference to an almanac and the star charts, but is a faint and uninteresting telescopic object. Angular diameter,  $2\frac{1}{2}''$ ; opposition magnitude, 7.8.

**The Asteroids, or Minor Planets**, are all invisible to the naked eye except Vesta (oppos. magnitude  $6\frac{1}{2}$ ), being very minute. The most interesting is Eros, one of the smallest; its orbit is so eccentric that at times it approaches nearer to the earth than any other planet, and at its next favourable opposition (in 1931) will afford much the most accurate means of ascertaining the sun's true distance from the earth. In addition to being named, asteroids are also numbered, roughly in the order of their discovery (symbolised thus (36)), but only when the orbit is determined : till then they are designated by Roman letters. Originally a single letter and the year was used, then the double form AB to AZ, BA to BZ, and so on to ZZ (I omitted). In 1907, the second double alphabet was started, adding the year (1907 AA, &c.), and a third in 1916, now current ('1918 DT,' June 1918). The numbered asteroids now amount to about 900 (1918).

**Nebulæ** are faint, misty, patches of light, usually of irregular form. Some of these have been resolved by the most powerful telescopes into patches of exceedingly minute stars; others are known to be masses of incandescent gas. *Planetary Nebulæ* are circular in form—so called because they much resemble the disc of a planet as seen in a telescope.

The *White Nebulæ*, of which the Great Nebula in ANDROMEDA is a type, give a faint continuous spectrum more or less resembling that of a star, and seem to be composed of myriads of minute stars. Most of the white nebulæ have a spiral form, as shown by photography. The greenish or bluish nebulæ are of the 'gaseous' type and are chiefly composed of the unknown gas nebulum. They contain also hydrogen and helium. The Great Nebula in ORION is of this type.

The gaseous nebulæ tend to cluster in the plane of the Milky Way or Galaxy, but the 'white' nebulæ are chiefly found towards its north pole—approx. R.A. 12h. 43m., Dec.  $27^{\circ} 6' N.$  (1920). See examples, Notes on Star Charts.

**Coloured Stars.** Colour is an index to physical condition (see p. 8), white stars being the youngest and hottest, and deep red stars the oldest and coolest. Colour also affects twinkling, as explained in the next paragraph. The components of many double stars exhibit the curious phenomenon—sometimes optical—of being complementary in colour—orange and blue, or crimson and green, &c: examples are given in Notes on the Star Charts.

**Twinkling of Stars.** Though purely atmospheric in its origin, this phenomenon is of interest to astronomers as it is affected by the nature of the light emitted by each star, *i.e.*, by its spectrum. It has been found that white stars (Type I) twinkle most; yellow stars (Type II) slightly less, and red stars (Type III) least of all. Twinkling is least at the zenith, and in settled and calm weather; and greatest toward the horizon, and in unsettled and stormy weather: an auroral display also increases it. In addition, there is a seasonal change, a waxing and waning from mid-summer to mid-winter and *vice versa*. The planets usually do not twinkle unless low down, supposed to be due to their having discs of appreciable size.

**The Green Flash,** or 'Green Ray,' is a beautiful solar phenomenon analogous to twinkling, and like it due to atmospheric causes. It is occasionally seen for a few moments before the instant of sunset or sunrise; but is more often visible if an opera-glass is used. The duration may be from a moment to several seconds. The general conditions required are a distant, sharply-defined, and low (preferably sea) horizon: the sun should not be looked at till the last moment. Cool weather and absence of red tints seem to be favourable, but not essential, conditions. Sometimes it takes the form of a *white* flash followed by a deep blue one. A red flash is sometimes seen as the sun's *lower* edge emerges from a dark cloud near the horizon.

**Comets** vary in brightness, most of them being visible only with the aid of a telescope. A comet is generally first discernible as a minute, faint, misty patch of light, so much resembling a nebula that it is only identified as a comet when found to be in motion, but sometimes even a very large comet escapes detection at first by approaching us in the line of the sun. The essential portion of all comets is the *coma* or head, the misty patch of light already mentioned. In addition a *nucleus* may develop as it approaches the sun, *i.e.* a bright flame-like or star-like appearance within the *coma*, and also a tail, or sometimes several tails—which always point more or less away from the sun, no matter whether the comet is approaching or receding from the sun. The tail usually appears as a curved hollow cone, decreasing in brightness as it widens out. Both nucleus and tail, when present, increase in size and brightness as the comet nears the sun, and decrease as it recedes from the sun; *envelopes*, or stratifications of the mist round the nucleus, especially on the side towards the sun, may also appear as the comet approaches perihelion. Neither nucleus nor tail, however, is necessarily present. Several comets are connected in some way with meteoric showers.

Entirely new comets are usually named after their discoverer, as Donati's comet, 1858. The comets seen during any year, whether new or already known, are also denoted:—(1) by the order in which they are discovered during that year, small Roman letters being used instead of numbers: Comet 1918 *a*, was the first comet seen that year, Comet 1918 *b*, the second, and so on. (2) By the order of their arrival at perihelion, using Roman numerals, I, II, &c., as Comet 1918 I.

*Periodic comets*—those which revolve round the sun, and thus appear at regular intervals—are known by the name of their discoverer (as *Holmes' comet*), or discoverers at two different returns (as *Pons-Brook's comet*), or discoverer or investigator of the periodicity (as *Halley's* and *Encke's Comets*). Tempel I (1867), Tempel II (1873), indicate two discoveries by the same observer. *Biela's comet* (now lost), which divided in two, was known as Biela I and II.

**Meteors or Shooting Stars** are of all degrees of brightness, from the faintest, lasting an instant, to the *bolide* or brilliant fireball, lasting several seconds: those that reach the earth are called *aerolites*. Meteors may appear in any part of the sky, but there are certain well-marked points on the star sphere from which showers of meteors come every year at regular dates, when the earth returns to the same part of its orbit. These showers are named from the constellation in which their *Radiant Point* or *Radiant* lies—so called because the meteors of the shower appear to radiate in all directions from that point in the sky. Meteors are generally twice as frequent at 6 a.m. as at 6 p.m., because at the former hour we are facing in the direction of the earth's motion in its orbit; in the latter, to the rear.

The Table on p. 19 gives a few of the principal showers that may be looked for, and the approximate position of their *Radiants*. In recording the appearance of a meteor, the unskilled should note that it is much more important to describe exactly its apparent path or track among the stars, from beginning to end, than its physical appearance.

**The Zodiacal Light** is not well seen in temperate latitudes, except near the time of the equinoxes. It appears as a faint, hazy, conical, beam of light which follows the course of the ecliptic on the star sphere, for 90° or more from the horizon where the sun has set (in spring), or will rise (in the autumn). It has been estimated as being, in its brightest parts, two or three times as luminous as the Milky Way, and is most probably due to sunlight reflected from meteoric bodies revolving round the sun. Its brightness seems to vary from time to time, and towards its extreme limits it is always exceedingly faint. Owing to its vertical, or almost vertical, position and the short duration of twilight, it is brighter when observed within the tropics than in temperate latitudes.

The 'Counter-glow' or *Gegenschein* is a *very* faint round patch of light,  $10^{\circ}$ - $20^{\circ}$  in diameter (*i.e.*, larger than the 'Great Square of Pegasus' =  $\alpha$ ,  $\beta$ ,  $\gamma$ , PEGASI and  $\alpha$  ANDROMEDÆ), situated on the ecliptic at the point diametrically opposite to where the sun is for the time being. It is very difficult to see, and cannot be distinguished if projected on the Milky Way: choose a moonless night of exceptional clearness, when the ecliptic is highest above the horizon, *viz.*, in December and January. It also is possibly due to sunlight reflected from meteoric bodies.

The Milky Way or Galaxy (see Index Maps, on front and back boards) extends right round the star sphere. Between CYGNUS and SCORPIO it forms two narrow parallel bands; thereafter for a considerable distance it is very much broken up and complex in form, but brighter. In CANIS MAJOR it again becomes a single but fainter band. The telescope shows that it is composed of myriads of minute stars, of the 10th and 11th magnitude on the average.

The *Coal Sack*, a remarkable gap (starless to the naked eye) in the Milky Way, near the foot of CRUX, appears like a dark abyss in the surrounding brightness. There are similar but smaller starless gaps in CYGNUS, and elsewhere.

The *North Galactic Pole* ('Uranometria Argentina' positions) is R.A. 12h. 43m., Dec.  $27^{\circ} 6'$  s. (1920) in COMA BERENICES; the *South Galactic Pole*, R.A. 0h. 43m., Dec.  $27^{\circ} 6'$  s., in SCLPTOR; the *Galactic Plane*, or Galactic latitude  $0^{\circ}$ , as follows (for 1875):—(18h. 30m., 19h., &c., are same as 6h. 30m., 7h., and so on, but making N. Dec. south, and *vice versa*).

R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.
6h. 30m.	$5^{\circ} 28' N$	8h. 30m.	$41^{\circ} 26' s$	10h. 30m.	$58^{\circ} 23' s$	12h. 30m.	$62^{\circ} 37' s$	14h. 30m.	$59^{\circ} 50' s$	16h. 30m.	$46^{\circ} 21' s$		
7 0	8 56 s	9 0	47 48 s	11 0	60 13 s	13 0	62 30 s	15 0	57 50 s	17 0	39 36 s		
7 30	22 10 s	9 30	52 23 s	11 30	61 29 s	13 30	62 7 s	15 30	55 6 s	17 30	30 38 s		
8 0	33 3 s	10 0	55 51 s	12 0	62 16 s	14 0	61 3 s	16 0	51 22 s	18 0	19 8 s		

The Magellanic Clouds, or *Nubecula Major* and *Nubecula Minor*, appear to the naked eye like detached portions of the Milky Way, and are a marvellous sight in the telescope, being made up of nebulae and star clusters, both regular and irregular in shape. Their respective positions are R.A. 5h. 30m., Dec.  $70^{\circ}$  s., and R.A. 0h. 50m., Dec.  $73^{\circ}$  s., and they are therefore not visible from the latitude of Europe or the United States.

**Transits of Mercury and Venus.**—Transits of *Venus* happen twice at the short interval of eight years and then do not recur for over 100 years ( $105\frac{1}{2}$  and  $121\frac{1}{2}$  alternately). Last transits, 1874, 1882; next transits, 2004, 2012.

*Mercury* transits the sun about four times in 33 years, and at the *same node* at intervals of 7, 13, 33 or 46 years. The transits always happen at the descending node in May, or at the ascending node in November. Transits take place in May 1924, 1937, and 1970, and in November 1927, 1953, 1960 and 1973.

**Occultations** take place when the moon or a planet passes directly between us and some other heavenly body, shutting it out from view. Occultations of stars by the moon are frequent, and their times are given in almanacs: the disappearance always takes place on the east side of the moon and the reappearance on the west. Where the star occulted is bright, the disappearance and reappearance, being instantaneous, are of great interest.

*Eclipses* of satellites, as distinguished from occultations, take place when they enter the *shadow* of their planet, and become invisible merely because the sun no longer shines on them, though nothing intervenes between them and us.

**Eclipses.**—*Total* and *annular* solar eclipses are so rarely visible from any given place that they need not be described in detail. Under the most favourable conditions, about three to four hours elapse between first and last contact, but the total phase never exceeds 7 m. 40 secs. in a total eclipse, or  $12\frac{1}{2}$  minutes in an annular eclipse, and is usually much less. At the equator, both totality and contact interval last about a quarter longer than at latitude  $50^{\circ}$ . *Partial* solar eclipses are of little interest unless nearly total: the sun merely appears as if it had a notch cut out of it.

*Lunar* eclipses, when total, last about four hours, from first to last contact, of which totality is for about two hours. Through the telescope, the earth's shadow may be seen sweeping slowly across the moon's disc, but its edge is not sharply defined. Usually the moon does not altogether disappear from view, even at mid-eclipse, but shines with a dull reddish-orange or greyish light, being illuminated by sunlight refracted by the earth's atmosphere: the colour and brightness depend on the amount of water vapour and clouds present in the earth's atmosphere at the time.

The *umbra*, or *shadow*, in solar and lunar eclipses, is the dark shadow on that portion of the earth or moon which, for the time being, receives no direct light from the sun. The umbra shades away into the bordering *penumbra* or partial shadow, which covers those regions whence the sun would be seen partially eclipsed. The *magnitude*, or extent, of an eclipse is indicated by expressing the area eclipsed as a decimal of the full area of the disc.

*First Contact* occurs, in a solar eclipse, at the instant when the discs of the sun and moon first appear to touch, *i.e.*, when the eclipse begins: *Last Contact* at the instant of the end of the eclipse. In the case of a lunar eclipse, we have two First Contacts—at the instant when (1) the penumbra, and (2) the umbra or shadow, first touch the moon's disc; and similarly two Last Contacts, at the moment when the penumbra and shadow, respectively, leave the disc.

The Sun, as an object for small telescopes, is of little interest unless sunspots are visible: special precautions are required in observing it so as not to injure the eyesight (see p. 18).

In large telescopes the disc of the sun presents a granular or 'rice-grain' appearance. Even in a small telescope of 2 or 3 inches aperture, the surface of the sun will shew a mottled appearance, when the air is steady and definition good; but this mottling is of a coarser texture than that delicate granular appearance seen under higher powers with large instruments. *Faculae*, i.e. irregular patches somewhat brighter than the average, may generally be seen. They are found on every part of the disc, but are best seen near the 'limb' or edge of the sun's disc, owing to the decrease in brilliancy of that part, arising from the sun's absorbent atmosphere.

*Sunspots* vary in size from small 'pores,' as the smallest are termed, to groups so large as to be occasionally visible to the naked eye. They present the appearance of a dark irregular spot, or *umbra*, surrounded by a less dark portion, or *penumbra*; the *umbra*, however, is only apparently dark, by comparison with its surroundings, being actually brighter than the electric arc. Occasionally they are visible as a small notch on the sun's edge, when just coming into view from the far side of the sun. Sunspots are never seen at the sun's poles, and rarely at its equator, being mostly confined to zones extending about  $20^\circ$  on each side of the solar equator. They wax and wane in number and intensity, at times none being visible, attaining a maximum or minimum about every 11 years, with intermediate minor fluctuations (last minimum 1913). There is a connection between them and terrestrial magnetism—as yet unexplained.

The sun's rotation may be traced by the daily apparent motion of the spots across the disc, the rotational period being about 25 days near the equator, and 27 days at  $45^\circ$ . Spots may thus be visible for almost a fortnight at a time.

*Prominences* or *protuberances* are jets or clouds of glowing red gas which rise all round the sun's 'limb' or edge. They can be seen only during total eclipses, or by means of a spectroscope attached to the telescope. (See p. 18).

The *Corona*, also seen only during total eclipses, is a mysterious, irregular, pearly halo of light surrounding the sun. It is never quite the same, either in shape or extent, in successive eclipses, and appears to be partly gaseous, and partly meteoric, for it shines partly by reflected sunlight. It varies with the period of the sun's activity, averaging 11 years, being more or less regularly distributed round the sun at sun-spot maximum, while at sun-spot minimum there are large streamers, several degrees long, near the sun's equator, with tufts or plumes of light near its poles.

The *Solar Apex*, or direction in which the sun is moving in space, seems to be about R.A. 18-19 hrs, Dec.  $35-50^\circ$  N.

The Moon is the most interesting of all the heavenly bodies for a small telescope. In an opera-glass the dark portions visible to the naked eye are seen to be the smoother portions of the moon's surface, the remainder of the surface is a mass of craters of every size, from some of which brilliant white streaks radiate for a great distance.

The best time for viewing the moon is when it is about its first or last quarter, as the lunar mountains near the *terminator* (or boundary between the bright and dark portion) then cast long sharp shadows which give a fine effect of contrast with the bright portions. At the time of full moon this contrast is lost. A low power should be used in the first instance for a general view.

The moon always presents the same side to the earth, so that one side of the moon is never seen at all. Owing, however, to what is termed the moon's *libration*, or apparent swaying, owing to the inclination of its axis to its orbit, and to other causes, we sometimes see a little more on one side or another, so that altogether about six-tenths of the surface is visible at one time or another. A full description of the moon with its great wealth of details is quite beyond the scope of the present work, but the following paragraphs, together with the map, and further notes, p. 21, indicate the principal features.

Lunar *plains*, the darker and smoother portions of the surface, were supposed by the early telescopists to be *seas*—which they much resemble under very low powers—and were named accordingly. More perfect instruments, however, revealed that the supposed seas were simply vast plains, by no means level, or smooth, possibly once the bottom of lunar oceans.

Lunar *mountain ranges* and peaks are much higher in proportion to the moon's diameter than terrestrial ranges are to the earth's diameter, some of them attaining a height of about five miles. The most conspicuous range is *The Apennines*, in the northern hemisphere of the moon, which rises like a wall from the *Mare Imbrium*. It is about 600 miles long, and its highest peaks attain a height of  $3\frac{1}{2}$  miles—the heights being found by measurements of their long sharp shadows, nearly 100 miles long.

Lunar *craters*, which are such a prominent feature in lunar landscapes, are of all sizes from a hundred and fifty miles in diameter downwards. Craters often have one or more conical peaks within the crater walls, of which *Tycho* and *Gassendi* are fine examples; the largest with a fairly level bottom, and often no central peak, and with

lower bounding walls than the craters proper, are called *walled plains*, of which *Plato* is the best example. The interiors of the craters are usually lower than the surface outside, but sometimes the reverse is the case. Frequently an old crater will be seen that has been broken into by a later one.

Lunar *rills* are deep, winding, narrow valleys, resembling the bed of a dried up stream. Lunar *clefts* appear like cracks on the smoother portions of the surface. It is difficult to realise that these hairlike markings are sometimes fifty or a hundred miles long and up to  $2\frac{1}{2}$  miles in width. The greater number of clefts are to be seen only in pretty powerful telescopes. *Faults* are closed cracks in the moon's surface, and are numerous. They are visible owing to the surface on one side of them being higher than that on the other.

Lunar *rays* are the bright streaks which radiate from some of the principal craters. Unlike other lunar features, they are best seen about the time of full moon. The finest system of rays radiates from the great crater *Tycho*, in the southern lunar hemisphere. The strangest feature of these rays is that they are everywhere on the same level as the rest of the surface, and traverse unbroken both crater walls, valleys, and seas. No fully satisfactory explanation of their nature has yet been given.

#### IV. THE CARE AND USE OF THE TELESCOPE.

THE following brief notes are given in the hope that they may be of use to the inexperienced observer:—

Telescopes are of two kinds—refracting and reflecting. Both varieties are rated according to their “aperture,” as the *clear* diameter of the large lens in refracting telescopes, or of the mirror in reflecting telescopes, is called.

The larger the aperture, the more powerful the telescope in rendering visible faint objects; and, as this power increases in proportion to the *square* of the diameter, a telescope of 3 inches aperture is more than twice as powerful as one of 2 inches, while a 4-inch aperture is nearly twice as powerful as a 3-inch, or four times as powerful as a two-inch one—the actual ratios being 4, 9, 16. For astronomical purposes, a 3 inch telescope may be considered as about the smallest that can be used with satisfaction, though pleasing views of many objects may be obtained with even smaller telescopes of good quality.

##### THE REFRACTING TELESCOPE.

The astronomical refractor essentially consists of two convex lenses—(i) a large one of considerable focal length, known as the *object glass*, which forms at its focus an image of the distant star or other object, and (ii) a small lens of much shorter focal length: this is called the *eye piece*, and is used to magnify the image formed by the object glass.

**The Object Glass.**—This is the most important part of the telescope, as its excellence depends on the accuracy of the curves of the lenses, the highness of their polish, and their transparency. In all astronomical telescopes worthy of the name, the object glass is “achromatic;” that is to say, it is composed of two (sometimes three) lenses of equal size but made of glasses of different density. These are so proportioned as to form an image almost free from the false colours, which are inevitably present when a bright object is viewed through an object glass consisting of a single lens. A good object glass requires to be treated with the most scrupulous care, and the notes on the care of the telescope on p. 17 should be carefully followed.

##### THE REFLECTING TELESCOPE.

In this form of telescope a large, concave, parabolic-curved mirror takes the place of the object glass of the refracting telescope.

The large mirror is held in a cell at the lower end of the large tube. The rays of light from the object pass down the tube and are reflected back. The reflected, convergent rays are intercepted—

- (1) In the “Newtonian” form of telescope by a small, elliptical, plane mirror, or “flat,” which reflects them at right angles through the side of the telescope to the eye-piece.
- (2) In the “Gregorian” form by a small concave mirror, or (3) in the “Cassegrainian” form by a small convex mirror, which reflects them back again, through a hole in the centre of the large mirror, to the eye-piece.

The Newtonian and Cassegrainian forms give an inverted image, similar to that of the refracting telescope: the Gregorian, however, gives an erect image.

## EYE-PIECES.

As already mentioned, these are used to magnify the image formed by the object glass, or the large mirror. For very high powers, and in special cases, a single lens is sometimes used; but generally an eye-piece consists of two lenses, mounted in a short tube which screws or slips into the focussing-tube of the telescope. There are several varieties, but the most common are:—

**The Huyghenian or negative eye-piece.**—This is the most common form, and consists of two plano-convex lenses, having their flat surfaces towards the eye.

**The Ramsden or positive eye-piece.**—Which gives a ‘flatter’ field than the Huyghenian (*i.e.* the field of view visible through it is not so blurred around the edges when the centre is sharply focussed), and, when of achromatic construction, performs excellently on planets.

As seen in an astronomical telescope with either of these eye-pieces, an object is inverted. To make it appear the right way up involves the use of additional lenses, which means some loss of light and a slightly fainter image, without any compensating gain.

**The magnifying power of a telescope** depends entirely upon the ratio of the focal length of the object glass to that of the eye-piece: thus, with an object glass of 36 inches focal length, and an eye-piece having a focal length of  $\frac{1}{2}$  inch, the magnifying power will be 72 diameters, or “power 72” as it is termed.

It is advisable to have at least three eye-pieces of different power:—

- (1). One of low power with a large “field,” (that is, showing a considerable area of the sky), for viewing comets, large and scattered clusters, and extended nebulae, magnifying 8 or 10 times per inch of aperture. Thus, on a 3 in. telescope the power may be from 25 to 30.
- (2). One of moderate power, magnifying 25 or 30 times to each inch of aperture.
- (3). One of high power, magnifying 50 or 60 times to each inch of aperture.

When experience has been gained, the observer may sometimes use eye-pieces of still higher power, but, as a rule, to advantage only on close double stars, when the telescope is of excellent quality and the atmospheric conditions are most favourable. The extreme limit of useful power is about 100 diameters per inch of aperture. It must be remembered that, as the power is increased, a corresponding apparent increase takes place in any defects of the telescope, the vibrations of the stand or ground, the rate of motion of a star across the field, and of atmospheric disturbances.

**To find the focal length of the object glass or mirror.**—Remove the eye-piece, and stretch a piece of semi-transparent paper over the end of the draw-tube. Point the telescope at the sun, and focus the sun’s image on the paper screen. The measured distance between the back of the object glass and the screen is, for practical purposes, the focal length of the object glass. In the Newtonian Telescope, the distance is measured from the centre of the surface of the large mirror to the centre of the surface of the flat, and thence to the screen, placed as above.

**To find the focal length of a Huyghenian eye-piece.**—Divide twice the product of the focal lengths of the two lenses by the sum of their focal lengths: the quotient is the focal length of an equivalent single lens.\*

**To find the power of an eye-piece.**—Make a scale with plainly-marked equal divisions. Set this up at a considerable distance away, and, holding both eyes open, view the scale through the telescope with one eye and directly with the other. The number of divisions on the scale, covered by the magnified image of one of them, is equal to the magnifying power of the eye-piece used. For measuring low powers, a distant brick wall will take the place of the scale.

Another method.—Focus the telescope on a star. Next morning, without altering the focus, point the telescope to the bright sky. When the eye is placed about 10 inches behind the eye-piece, there will be seen a small, clearly-defined disc of light. Measure the diameter of this disc by means of a Berthon Dynamometer (see p. 17) placed against the eye-piece—a pocket lens, of low power, should be used as an aid in doing this. The magnifying power of the eye-piece is found by dividing the clear diameter of the object glass by the measured diameter of the bright image.

**Diameter of field.**—To ascertain the diameter of the field of an eyepiece, observe how long a star situated

\* This is on the assumption that the distance apart of the lenses is equal to half the sum of their focal lengths. I am indebted to the Rev. W. F. A. Ellison for pointing out that in the case of many eye-pieces this distance is not kept to by the opticians, and that the correct formula for all combinations is:—Focal length =  $\frac{f^1 \times f^2}{f^1 + f^2 - d}$ , where  $f^1$  and  $f^2$  are the focal lengths of the lenses and  $d$  their distance apart.

near the equator (e.g.  $\delta$  ORIONIS) takes to pass centrally across the field from one side to the other. This time, expressed in minutes and seconds, when multiplied by 15, will give the diameter of the field in minutes and seconds of arc.

### TESTS.

The actual performance of a telescope on a celestial object is the only really satisfactory test. Seen through a telescope bearing its highest power, a fixed star of the second magnitude should appear as a minute, well-defined, circular disc of light, almost a point, and surrounded by one or two thin, concentric, bright rings. There should be no false rays of light, and the rest of the field should be uniformly dark. The telescope should not, however, be condemned too hastily, as an inferior eye-piece, or the state of the air (see p. 17), may be responsible for apparent defects in the object glass. A close double star with very unequal components forms a most severe test. A telescope of the finest quality should separate a double, consisting of two 6th magnitude stars, whose distance from centre to centre in seconds of arc is equal to 4.56 divided by the aperture expressed in inches: thus, a 3-inch telescope should just divide a double star whose components are 1.52" apart.

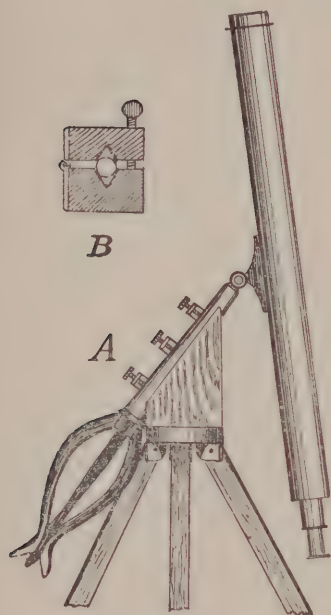
### ACCESSORIES.

**Stands.**—Much depends upon the rigidity of the telescope stand, and good observations must not be expected from the open window of an ordinary room, as the vibration of the floor, and the mixed currents of air, set the object being viewed dancing. For small telescopes, the ordinary, alt-azimuth, tripod garden stand is most convenient. An iron pipe of about 4 inches diameter, partly sunk in the ground, and rammed full of clay to deaden vibration, forms a good support for a telescope of moderate size.

The "equatorial" stand is of enormous advantage, but is rather expensive. It has one of the pivots, or axes, which carries the telescope, directed towards the celestial pole, (being adjustable for latitude). The result is that a star may be followed by a single circular movement of the telescope, instead of the instrument having to be moved both in altitude and azimuth.

A tolerably satisfactory makeshift can be arranged (in the higher latitudes at least) with an ordinary tripod stand, by setting one leg to the pole-star, and then adjusting the other legs so that the *pillar* of the telescope is tilted over to point to the pole-star.

Or still better, by screwing on to the top of the stand a block of wood which is cut off at an angle, as shown in the illustration (A), and which has a V-groove, with sides at an angle of  $60^\circ$ , cut along the inclined face, for receiving the pillar. The claw legs of the stand, folded up, will act as a counterpoise, and two or three screw clamps will keep the pillar firm. A piece of hard wood (not shown in the illustration), also V-grooved, should be interposed between the point of the screws and the pillar, to prevent damage when tightening up the screws. A somewhat simpler construction is to hinge this upper block at one side to the lower block, and pass the screws through both blocks at the other side, as shown in the illustration at (B).



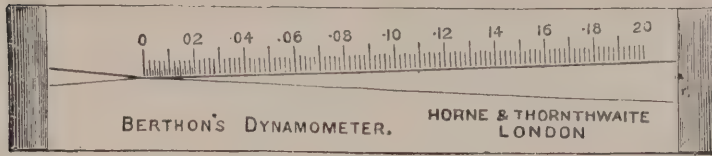
Improved Equatorial.

The angle of the sloping top, from the vertical, must be the latitude of the observer subtracted from  $90^\circ$ . Thus, for latitude  $52^\circ$  it will be  $90^\circ - 52^\circ = 38^\circ$ .

**Finder.**—A finder is a small telescope fixed by supports to the body of the larger instrument. When high powers are used, this adjunct is a necessity, and in all cases it adds much to the comfort of observing. The finder may be roughly adjusted by day on a distant weather-cock or some other definite object. To improve the adjustment, bring the polar star into the centre of the field of a low power eye-piece on the large telescope; then alter the direction of the finder, by means of the adjusting screws, until the star image is in the centre of the field of the telescope, and also bisected by the cross wires of the finder at the same moment. Now replace the low-power eye-piece by one of high power, and perfect the adjustments in the same way. For small telescopes up to 3-inch, 'sights' similar to those on rifles can be arranged (painted white), which will be found of some service.

**Dew-cap.**—To guard against the deposition of dew on the object glass, make a tube of tin, cardboard, or some such material, about 9 inches or 1 foot long, and of such a diameter as to fit closely, but not too tightly, on to the object glass end of the tube. The inside of the dew-cap should be covered with black velvet, or painted with a mixture of lamp-black and size. Black blotting paper is also suitable.

**Berthon's Dynamometer (or measuring gauge)** is a little instrument used for measuring the diameters of small objects. It has two flat metal sides, the internal straight edges of which meet towards the end, and are inclined to each other at a small angle. One of the edges is graduated from 0 to  $\frac{2}{10}$  of an inch. The figures on the scale



denote the width of the gap between the two straight edges. To measure the diameter of any small object by means of this little appliance, it is only necessary to see at what part of the scale the object *just* fills the space between the internal edges of the gauge, and then take the reading from the scale. The

scale is divided into 20 long divisions of  $\cdot 01$  or hundredths of an inch. These are subdivided into five parts each equal to  $\cdot 002$  or five-hundredths of an inch. The first two long divisions are again divided into parts equal to  $\cdot 001$  or thousandths of an inch. The price is 7/6.

### HINTS ON CLEANING.

**Refracting Telescope.**—A good object glass is so delicately figured that it should be cleaned as rarely and carefully as possible, for fear of affecting the accuracy of its form. (*See below, "Cleaning."*)

The lenses should never be taken out of their cell by an inexperienced person.

The object glass should be held in its cell with just sufficient "play" for a slight rattle to be heard when it is gently shaken. If screwed up tightly, it causes strains in the glass which mar the perfect definition.

**Reflecting Telescope.**—The silvered mirror requires to be kept with very special care, as the silver is exceedingly liable to tarnish, especially in or near large towns, from the sulphurous fumes in the air. The owner of a reflecting telescope should, therefore, procure and study the "Hints on Reflectors," which have been published by several of the leading makers of these instruments.

A slight stain causes merely an inconsiderable loss of light, but, if badly tarnished, the mirror must be re-silvered. This process may be successfully accomplished by the amateur, with little difficulty, and at no great expense, if he carefully follows the directions given in the books just referred to, and uses pure chemicals.

**Care of the Telescope.**—Before removing the telescope after the night's work, cover the object glass or mirror with the metal cap provided for that purpose.

Never take the instrument from the cold outer air into a warm room, or the object glass will become dewed. If this should happen, the object glass must not be left in that state; but it should be placed in a warm room, at a safe distance from a fire, until the moisture has vanished. Any stains left on the glass must be removed by gentle polishing. Never wipe an object glass when it is damp.

**Cleaning the Lenses.**—When it becomes necessary to clean these, any dust should first be removed by means of a *camel's-hair brush*. Then the lens should be wiped very gently with a piece of very fine and clean wash-leather or silk.

When not in use, all brushes and materials employed for this purpose should be carefully protected from dust by keeping them in clean stoppered bottles or air-tight cases.

### HINTS ON OBSERVING, &c.

**Atmospheric Conditions.**—To get the best results, objects should be viewed when they are as far as possible above the horizon, *i.e.* when near culmination. Satisfactory observations cannot be made of objects at low altitudes, owing to the increased intervening thickness of the atmosphere, and the haze and mist which so often obscure the horizon. The nights when the sky is darkest, and the stars most brilliant, are by no means always the best for observational purposes. Faint and ill-defined objects, such as some nebulae, may, however, often be seen to advantage on nights of this class.

When the stars twinkle much it is an indication that the air is unsteady and not altogether satisfactory for observation.

During a slight haze, the air is often very steady, and splendid views of bright objects may then be obtained.

**Viewing Faint Objects.**—The eye becomes much more sensitive to faint impressions after it has been kept in the dark for a considerable time.

Very faint objects, otherwise invisible, may sometimes be detected by averted vision: the eye is directed to another part of the field, while the attention is fixed on the spot where the object is supposed to be.

A slight change of focus is often restful to the tired eye.

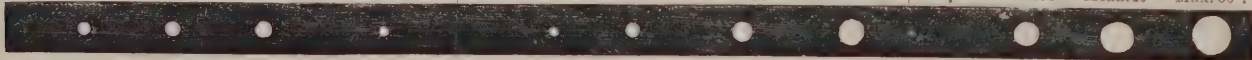
**Viewing the Sun.**—It is extremely dangerous to attempt to view the sun unless proper precautions are taken: blindness may be the penalty of rashness or ignorance. A perfectly safe method is to support a smooth, white card, at the distance of about a foot from the eye-piece, and to focus the image of the sun projected on it. The screen should be held in a covered frame-work or box, and the picture of the sun viewed through a hole in one of the sides. If, on the other hand, the sun is viewed directly through a dark-glass cap, a larger aperture than 2 inches cannot safely be used in the heat of summer. A stop made of a card, with a circular hole of 2 inches or less in diameter, should be fitted over the object glass of a larger instrument, to reduce the amount of light and heat transmitted.

To see the prominences by means of the spectroscope, the edge of the sun's image should be made to fall on the nearly-closed slit of the spectroscope—which must be one of considerable dispersive power. The telescope should then be driven (preferably by clock-work) so as to keep the image in the same position. The spectroscope is next focussed on one of the hydrogen lines of the spectrum, and, on the slit being opened, the prominence will be seen. Good views may be obtained in this way, using a 3-inch telescope with a spectroscope having several prisms.

**Comet-seeking.**—In searching for comets, a telescope of fairly large aperture and of short focal length, with an eye-piece of low power having a large field of view, should be used. The observer should slowly 'sweep' (*i.e.* move the telescope in a horizontal direction) for some distance, a careful watch being kept all the time. At the end of the sweep the telescope is *slightly* raised or lowered, and an overlapping sweep is taken in the opposite direction. This process is repeated continuously. Should a nebulous-looking object be noticed, the comet-hunter must look in his catalogue of nebulae to see if the object can be identified. If not, he should draw a careful sketch of its position among the neighbouring stars. If in the course of time any movement can be detected, and the place of the suspected object does not agree with that of any known comet, its position should be determined as accurately as means will allow, and a telegram giving particulars should be sent to the Astronomer Royal, Greenwich Observatory.

**Observing Mars, &c.** The angular diameter of the disc, on any date, is obtained by doubling the semi-diameter given in almanacs. The diagram indicates, on a uniform scale, the range of changes, and relative sizes, of the discs.

Saturn. Min. 15" Mean. 18" Max. 21". Uranus. 3½". Mars. Min. 4" Mean. 17" Mean. opp. 23" Max. 30". Jupiter. Min. 30" Mean. 40" Max. 50".



**North Preceding, &c.**—In describing how to find celestial objects, the often-used phrase "North (or South) Preceding," "North (or South) following," a certain star, means that the object is nearer the North or South celestial pole than the star referred to. "Preceding" means that its Right Ascension is *less* than, and "following" *greater* than, that of the reference star, and indicates the direction in which to find the required object.

Observers in the Northern Hemisphere must remember that in the inverted view of an object, as seen in astronomical telescopes (except "Gregorians," see p. 14), the upper part of the field of view is south, while the lower part is north. To observers south of the Equator, however, the reverse is the case.



Between rising and culmination.  
(Angle depending on latitude of observer and declination of star.)

Southing or culminating.  
(Upright.)

Between culmination and setting.  
(Angle depending on latitude of observer and declination of star.)

n. p. = North preceding. n. f. = North following. s. p. = South preceding. s. f. = South following. P = West. F = East.

Diagram showing direction of motion of a star across the field of an *inverting* astronomical telescope used in the Northern Hemisphere. In the Southern Hemisphere, hold the book upside down.

In the diagram, the arrow denotes the apparent path of a star as it crosses the field of view of a fixed telescope in the Northern Hemisphere. This path will be horizontal only when the object is on the meridian, but the relative positions remain unchanged.

**Observing Meteors.** The following are the important points to note. Date; Greenwich Mean Time (G.M.T.) of appearance. R. A. and Dec. of beginning and end of flight, and duration in seconds; colour and stellar magnitude, stating comparison star; path, if straight or wavy; trail, if any, and its colour, duration, direction and speed of drift; any other notes. R.A. should be stated in degrees (see conversion Table below), and the observation communicated to the Director of the Meteoric Section of the British Astronomical Association.\*

For counting seconds, the well-known photographic rule 'One, two, three, ONE; one, two, three, TWO; &c.', pronounced rapidly but distinctly, will give very near results. The following are some of the principal showers:—

Date of Shower.	Name.	Position of Radiant.			Date of Shower.	Name.	Position of Radiant.		
		R.	A.	Dec.			R.	A.	Dec.
Jan. 2-3	Quadrantids	15	20	53° N.	July 25-30	♂ Aquarids	22	36	11° S.
„ 17	κ Cygnids	19	40	53° N.	Aug. 10-12	Perseids	3	0	57° N.
Feb. 5-10	α Aurigids	5	0	41° N.	Aug. 12-Oct. 2	α Aurigids	4	56	42° N.
April 20-22	Lyrids	18	4	33° N.	Aug.-Sept.	Lacertids	22	8	49° N.
May 6	γ Aquarids	22	32	2° S.	Oct. 2	Boötids	15	20	52° N.
„ 11	α Coronids	15	24	27° N.	Oct. 18-20	Orionids	6	8	15° N.
„ 30	η Pegasids	22	12	27° N.	Nov. 13-15	Leonids	10	0	22° N.
June-Sept.	γ Draconids	17	56	48° N.	Nov. 17-27	Andromedes	1	40	43° N.
July-Aug.	Cygnids	21	0	48° N.	Dec. 10-12	Geminids	7	12	33° N.
July 25-Aug. 4	α-β Perseids	3	12	43° N.					

*Note.*—The Perseids, Orionids, Geminids, and several other showers, are visible every year about the time given. The Leonids, or November Meteors, were plentiful in 1799, 1833 and 1866, being seen at their best at intervals of about 33 years. In 1900 the display was not brilliant, owing to the disturbance of their orbit by the planet Jupiter.

### Right Ascension Degrees Converted into Hours and Minutes.

h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1° = 0 4	6° = 0 24	12° = 0 50	50° = 3 20	100° = 6 40	140° = 9 20	190° = 12 40	230° = 15 20	280° = 18 40	320° = 21 20				
2 0 8	7 0 28	15 1 0	60 4 0	105 7 0	150 10 0	195 13 0	240 16 0	285 19 0	330 22 0				
2½ 0 10	7½ 0 30	20 1 20	70 4 40	110 7 20	160 10 40	200 13 20	250 16 40	290 19 20	340 22 40				
3 0 12	8 0 32	30 2 0	75 5 0	120 8 0	165 11 0	210 14 0	255 17 0	300 20 0	345 23 0				
4 0 16	9 0 36	40 2 40	80 5 20	130 8 40	170 11 20	220 14 40	260 17 20	310 20 40	350 23 20				
5° 0 20	10° 0 40	45° 3 0	90° 6 0	135° 9 0	180° 12 0	225° 15 0	270° 18 0	315° 21 0	360° 24 0				

**Observing New Stars (Novæ).** The following changes generally occur, in the spectra and colour:—

- |                                                        |                                                            |
|--------------------------------------------------------|------------------------------------------------------------|
| 1. Continuous spectrum: ... .. White                   | 6. Hydrogen lines fade: ... .. Orange                      |
| 2. Hydrogen lines double: bright and dark lines: White | 7. Nebula lines more prominent than hydrogen lines: Bluish |
| 3. Lines widen: continuous spectrum fades. ...         | 8. Star now a planetary nebula. ... ..                     |
| 4. Nebula lines appear: ... .. Yellow                  | 9. Nebula lines fade: spectrum becomes continuous.         |
| 5. Hydrogen lines brighten up: ... .. Red              |                                                            |

**List of Novæ.** Those before A.D. 1572 are more or less uncertain, as ancient records sometimes confuse Novæ and comets; some now supposed to have been comets are marked †. >1 means 'above 1st magnitude'; 'v. br.,' very bright.

Year. B.C.	Nova:—	Mag.	Position.	Year A.D.	Nova:—	Greatest Mag.	R.A.	Dec.	Year A.D.	Nova:—	Greatest Mag.	R.A.	Dec.
134	Scorpi†	1	near β	1572	Cassiopeia	>1	0h. 19m.	63° 35' N.	1901	Persei 2	>1	3h. 26m.	43° 31' N.
123	Ophiuchi	1	" α	1604	Ophiuchi	>1	17 27	21 25 S.	1903	Geminorum 1	5	6 39	30° 2' N.
				1670	Vulpeculæ	3	19 44	27 7 N.	1905	Aquila 2		18 58	4 34 S.
				1848	Ophiuchi	4	16 55	12 46 S.	1910	Sagittarii 2	7.5	17 55	27 33 S.
173	Centauri *	1	bet. α & β	1860	Scorpii (T)	7	16 12	22 47 S.	1910	Lacertæ	5	22 33	52 18 N.
386	Sagittarii v.br.		" λ & φ	1866	Coronæ (T)	2	15 56	26 10 N.	1912	Geminorum 2	3.3	6 50	32 14 N.
389	Aquilæ†	1	near α	1876	Cygni	3	21 39	42 28 N.	1918	Aquilæ 3	>1	18 45	0 29 N.
393	Scorpii v.br.		in Tail	1885	Andromedæ	7	0 38	40 50 N.					
827	"	1	...	1887	Persei 1	9.2	1 56	56 21 N.					
1006	"	-	...	1892	Aurigæ (T)	4	5 27	30 23 N.					
1012?	Arietis v.br.		...	1893	Normæ (R)	7	15 24	50 28 S.					
1203	Scorpii	1	in Tail	1895	Carinæ (RS)	8	11 4	61 30 S.					
1230	Ophiuchi	1	nr. Serpens	1895	Centauri (Z)	7	13 42	31 14 S.					
				1898	Sagittarii 1	4.7	18 57	13 16 S.					
				1899	Aquilæ 1	7	19 16	0 17 S.					

**Atmospheric Absorption: Estimating Magnitudes of Variable Stars and Meteors.**—For accurate valuation of magnitudes, if the comparison stars are not about the same altitude, allowance must be made for the difference, as atmospheric absorption diminishes the brightness by approximately the following magnitudes:—

Zenith distance.	47°	58°	64°	69°	71°	73°	75°	77°	79°	80°	84°	86°	88°	89°
No. of mags. diminished.	$\frac{1}{10}$ th	$\frac{2}{10}$ ths	$\frac{3}{10}$ ths	$\frac{4}{10}$ ths	$\frac{5}{10}$ ths	$\frac{6}{10}$ ths	$\frac{7}{10}$ ths	$\frac{8}{10}$ ths	$\frac{9}{10}$ ths	1 mag.	1½ m.	2 m.	2½ m.	3 m.
Altitude above horizon.	43°	32°	26°	21°	19°	17°	15°	13°	11°	10°	6°	4°	2°	1°

\* Registered address: 136 Rodenhurst Road, Clapham Park, London, S.W.4.

**Making Notes.** Consulting the Charts when observing, &c.—A bull's-eye lantern with a slide to shut off the light is of great use. A cycle lamp may be utilised by the occasional observer. It may be placed on a support at some distance from the observer, and so directed as to throw a *faint* light on the book or card, when notes or sketches are being made at the telescope. A photographic red lamp is even better, as it does not affect the sensitiveness of the eye.

A strong light should be avoided as it makes the eye less sensitive for observation.

A small table to hold the maps and other books, with a lantern having a shade to throw the light downwards, lest the direct rays of light should reach the eye, is almost a necessity; a special shelf may be fixed up in an out-house.

All observations should be written down at the time when they are made. The notes should be clearly worded, and should have entered on them the year, month, day, hour, and minute of the observation, together with the aperture and power of the telescope, and the state of the air.

**Star Catalogues** for stars, double stars, clusters, nebulae, variable and coloured stars, &c., are rather inaccessible to the ordinary observer, many being very expensive or found only in the journals of scientific societies. Some of the more important are given below: see also a long list in G. F. Chambers' 'Handbook of Astronomy,' Vol. II.

For star magnitudes, the best known works are Pickering's 'Harvard Photometry,' the 'Revised Harvard Photometry' and its supplement (1908)—which together contain the magnitudes, &c., of no fewer than 45,792 stars in both hemispheres—and Gould's 'Uranometria Argentina' (Southern Hemisphere).

Backhouse's Star Catalogue (Epoch 1900) can be had at a moderate price. It is intended to contain all stars visible to the naked eye; their magnitudes, which are given tabulated for comparison, being taken from the best authorities.

*Contraction.* With number added, = Number in—

A.G.	Astronomischen, Gesellschaft, Katalog der, 1875.
A.G.C.	Gould's Argentine General Catalogue of 32,448 Southern
Arg.	Argelander. (See B.D. below). [Stars, 1886.
B	Birmingham's Catalogue of Red Stars, 1877.
B.A.C.	British Association Catalogue of 1845.
B.D.	{ Argelander's Bonn 'Durchmusterung,' 1859-62,* ex- tended by Schönfield (1886) 2° to 23° Dec.
$\beta$	Burnham's Double Star Catalogues.
Br. or Bris.	Sir T. Brisbane's Catalogue of Southern Stars, 1835.
C.G.A.	Gould's 'Catalogo General Argentino,' 1886.
C.P.D.	{ Cape Photographic Durchmusterung. Southern Stars = 18° to 90° by Gill and Kapteyn, 1896-1903.
$\Delta$	Dunlop's Catalogues of Double stars and Nebulae, 1828.
E-B	{ Espin's Edition of Birmingham's Catalogue of Red Stars, 1888. [Published in 1838.
Gr.	Groombridge's Catalogue of Circumpolar Stars for 1810.
H	Sir W. Herschel's Catalogues of Double Stars, 1782-1822.
Houz.	Houzeau's Uranométrie Générale, 1878.
h	{ Sir J. Herschel's Catalogues of (1) Nebulae, 1833, 1847; and (2) of Double Stars.
H.P.	Pickering's Harvard Photometry, 1884.

*Contraction.* With number added, = Number in—

H.R.	(also 'R.H.P.'). Revised Harvard Photometry, 1908.
Jac.	Jacob's Catalogue of Double Stars, 1848.
Lac.	{ Lacaille's Catalogue of Southern Stars, published by the British Association, 1847.
Ll.	Lalande's Catalogue, pub. by the B.A., 1837.
M.	Messier's Catalogue of 103 Nebulae, pub. 1784.
N.G.C.	New edit. Sir J. Herschel's Cat. Nebulae & Clusters
P.	Piazzi's Star Catalogue, 1803-14. [(Dreyer), 1888.
ph.	Great International Photographic Star Map.
Rus.	Russell's Double Star Measures (Sydney), 1891.
S.	South's Measures of Double Stars, 1826.
Sa.	Santiago Observations, 1876.
S.M.P.	Harvard Southern Meridian Photometry, 1895.
St.	{ Stone's Cape Catalogue for 1880, or Radcliffe Catalogue for 1890.
U.A.	Gould's Uranometria Argentina, 1879.
U.O.	Pritchard's Uranometria Nova Oxoniensis, 1885.
$\Sigma$	F. G. W. Struve's Dorpat Catalogue of Double Stars, 1837.
$\Sigma I$	do. do. Appendix I.
O $\Sigma$	Otto Struve's Revised Pulkova Catalogue, 1850.
O $\Sigma\Sigma$	Pulkova Catalogue, Part II.

\*In this case the zone is stated as well as the number. Thus B.D. + 13° 2302 means Star No. 2302 in the 13° zone, north, in the B.D.

**'Size' of a degree on the star sphere.**—The following will be found useful for roughly estimating angular distances on the star sphere: others can easily be made up from the star charts. The degrees are those of a 'great circle,' such as degrees of declination, or degrees measured along the celestial equator or the ecliptic:—

$\frac{1}{2}^\circ$ = the angular diameter of the Moon.	$2\frac{1}{2}^\circ$ = approx. $\alpha$ to $\beta$ AQUILÆ; or $\alpha$ to $\delta$ RETICULI.
$1\frac{1}{4}^\circ$ = (approx.) $\delta$ to $\epsilon$ ORIONIS; or $\beta$ to $\lambda$ CRUCIS.	$4^\circ$ = „ $\alpha$ to $\beta$ CANIS MINORIS; or $\alpha$ to $\beta$ CRUCIS.
$2^\circ$ = „ $\alpha$ to $\gamma$ AQUILÆ; or $\alpha$ to $\sigma$ SCORPII.	$5^\circ$ = „ $\alpha$ to $\beta$ URSE MAJORIS; or $\alpha$ to $\beta$ CENTAURI.

**Table of Mean Refraction.** For 49° Fahrenheit, and barometer 29.6 inches. Refraction increases the lower the thermometer and the higher the barometer, and decreases *vice versa*. 'App. Alt.' = Apparent Altitude of star, &c.

App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.	App. Alt.	Refraction.
0°	34' 54"	3°	14' 15"	6°	8' 23"	9°	5' 49"	12°	4' 25"	15°	3' 32"	25°	2' 3"	40°	1' 9"	65°	0' 27"
1	24 25	4	11 39	7	7 20	10	5 16	13	4 5	16	3 19	30	1 40	45	0 58	80	0 10
2	18 9	5	9 47	8	6 30	11	4 49	14	3 47	20	2 37	35	1 22	50	0 48	90	0 0

## Astronomical Symbols and Contractions.

<i>Sun and Planets.</i>	<i>Signs of Zodiac.</i>	<i>Miscellaneous.</i>	<i>Miscellaneous.</i>	<i>Miscellaneous.</i>
☉ or ○ Sun.	♈ Aries.	♌ Conjunction, = 0°	☾ Mean longit. in orbit.	φ Angle of eccentricity,
☿ Mercury.	♉ Taurus.	difference in longit.	i Inclination.	or angle whose sine = <i>e</i>
♀ Venus.	♊ Gemini.	* Sextile, ... 60° do	L Long. of ascending node	Ω Long. of ascending node.
☾ Moon.	♋ Cancer.	□ Quadrature, 90° do	L } Mean longit. in orbit.	Ω } " descending "
♁ or ♂ Earth.	♌ Leo.	♍ Opposition, 180° do	l } " " "	ω Longit. of perihelion.
♂ Mars.	♍ Virgo.	Δ Trine, ... 120° do	λ Longitude (celestial).	+ Declination North.
♃ Jupiter.	♎ Libra.		μ } Mean angular motion	" " South.
♄ Saturn.	♏ Scorpio.	Δ Distance.	n } in unit of time.	Dec. Declination. [Time.
♅ Uranus	♐ Sagittarius.	β Latitude (celestial).	ν Long. of ascending node.	G.M.T. Greenwich Mean
♆ Neptune.	♑ Capricornus.	D Diameter.	π Longit. of perihelion	Mag. Magnitude. [tance.
♁ Minor Planet.	♒ Aquarius.	α Right Ascension.	ρ { Radius: radius vector.	N.P.D. North polar dis-
	♓ Pisces.	δ Declination.	R { " " "	N.A. Nautical Almanac.
		e Eccentricity.	T Time: periodic time.	R.A. Right Ascension.

*np* North preceding. *sp* South preceding. *nf* North following. *sf* South following.

## THE MOON.

**General Notes.** THE most striking views of the moon are obtainable when it is about its first or last quarter, when the lunar mountains near the *terminator* (or boundary between the bright and dark portions), cast long dark shadows which give a fine effect of contrast with the bright sun-lit parts. At the time of full moon this contrast is lost, though the systems of *rays* or bright streaks are then most in evidence, and an interesting field of study is the total, or nearly total, disappearance of prominent objects for 2 or 3 days before and after 'Full' (*e.g.*, Maginus), while others (notably the craters, properly so called, see p. 22) can still be located by reason of their being brighter than their surroundings. This disappearance is very noticeable in formations traversed by the rays or streaks, as in the S. W. portion of the Moon. A low power should be used at first, for a general view of the disc.

**Objects near the Limb.** Those near the N. lunar pole are best situated for observation when the Moon has its greatest south latitude (about 5°), and *vice versa* for the S. pole; those near the west limb, when the Moon's actual longitude is E. of (*i.e.*, greater than), and those near the east limb when it is W. of (*i.e.*, less than) the mean longitude.

**Repetition of same Phase** of illumination, near the same hour, may be expected in about 2 and 15 lunations, on the average, but there are variations—corresponding with the lengths of different lunations, which vary to and fro between 29½ and 29¾ days. The mean lunation is just over 29½ days, hence, on the average, the second lunation falls in daylight; the third is 1½ hours later in the evening, and so on. 1 mean lunation = 29<sup>d</sup> 12<sup>h</sup> 44<sup>m</sup>; 2 lunations, 59<sup>d</sup> 1½<sup>h</sup>; and 15 lunations, 442<sup>d</sup> 23<sup>h</sup>.

**Effects of Libration.** At each recurring phase, though the positions and lengths of the shadows themselves have not changed greatly (lunar 'seasonal' changes being small, owing to the small inclination of the lunar equator to the ecliptic, 1½°), the Moon's latitude and longitude, &c., have altered. Libration has come into play, and we see the object and its shadow in a different position, the variation amounting at its maximum to over 20°, through the combined effect of the displacement in latitude and longitude. Except at rare intervals, therefore, we do not re-observe objects under anything like the same conditions. When viewing the Moon, also, it should be remembered that it is only near the centre of the disc that we see objects in their true form and dimensions, as each object is more and more foreshortened the further it is away from the centre, and, on the limb, is only seen in profile.

**Earth-shine**, popularly known as 'the Old Moon in the New Moon's arms,' is due to rays of light reflected from the Earth on the Moon's dark disc. It is stronger in the morning with Old Moon than in the evening with New Moon, and its variations are worth systematic study, as an index to the reflective power of the Earth's disc, which is lit up by the Sun. As the albedo of clouds is very high (p. 6), unusual brightness probably indicates that the hemisphere is much cloudier than usual, and *vice versa* when earthshine is faint.

A very narrow ring of silver-white light, quite distinct from earthshine, and encircling the whole lunar disc, is occasionally visible for short periods when the moon is 2 to 3 days old.

**Lunar Nomenclature.** Lunar objects are generally referred to the *quadrant*, or quarter of the disc, in which they are found, numbered I to IV, as on the map. The principal formations have names of their own: other objects in the neighbourhood (also those *inside* or on a crater), not separately named, are denoted by the nearest crater name with a *Roman* letter added, for craters or depressions, or a *Greek* letter, for peaks or elevations—capitals denoting 'measured' points. Thus 'Aristoteles B' is different from 'Aristoteles,' being a small crater some 50 miles N. of the latter. Greek letters are also used for rills, in conjunction with the crater names.

**Lunar Mountains** are of two classes: (a) ordinary mountains—chains and smaller ranges, hills, ridges, peaks, &c., and (b) 'craters,' conventionally so called, with hollow centre, and central peak, or peaks—though this is sometimes absent, as in Plato. Craters are sub-divided into several types, but as these merge into one another, authorities classify some craters differently. In these sub-divisions, 'crater' is used in a special sense, to denote the type which seems most nearly to correspond to terrestrial craters. The more important types are:—

*Walled Plains* (marked † in Index) diameter 40-150 miles, usually surrounded by a complex succession of walls.

Floor usually not much lower than the outside, and comparatively level; central mountain often absent.

*Ring-Plains* (unmarked in Index) form the majority of lunar craters, diameter 20-60 miles. More uniform and circular than walled plains; generally surrounded by a single principal wall. Outer slope is small, interior steep and usually terraced, floor nearly always much lower than the outside, and comparatively level.

*Craters* proper (‡ in index); diam. 4-12 miles, circular, outer slope steep: floor small, with volcanic cone; a characteristic feature is brightness, which often enables them to be distinguishable at 'Full.'

The general description of the Moon given on page 13 indicates a few of the outstanding features. For fuller details refer to Neison's or Elger's books on the Moon, and Goodacre's Map of the Moon.

**Lunar 'Seas' and Valleys.** The Sinus Iridum, with great bounding cliffs, rising in peaks over 16,000 ft. high, is one of the finest objects on the Moon: it is best seen when the Moon is 8 or 9 days old.

Of the *valleys*, the Great Alpine Valley is the most notable. Most *clefts* or *rills*, and *faults*, are not visible in small instruments, but the Cleft of Hyginus, and the rill of Ariadeus just W. of it, can be seen in a two-inch telescope.

**The Brightness** of different parts of the moon is an interesting study: it is valued in 'degrees,' ranging from 1°, the darkest—found in Grimaldi and Riccioli—up to 10°, found in Aristarchus, the brightest object in the moon. 0° is black shadow. The floor of Plato undergoes curious changes in brightness as the altitude of the sun increases.

The varying colours of the Seas may also be studied. The prevailing tint is grey, more or less dark, Mare Crisium being the darkest ( $1\frac{1}{2}^{\circ}$ -3°), with a tinge of green. The brightest of the grey plains is Lacus Somniorum ( $3\frac{1}{2}^{\circ}$ -4°); Palus Somnii, equally bright, is of a yellow-brown shade. The Mare Serenitatis, the centre of Mare Humorum, and part of the Sinus Iridum, have a dark greenish colour, and the Mare Crisium a lighter green; the Mare Frigoris is yellowish-green.

**Centres of Principal Ray Systems.** Aristarchus, Aristillus, Byrgius A, Copernicus, Euler, Kepler, Messier, Proclus, Timocharis, and Tycho. Euclides and Landsberg A are surrounded by a 'nimbus,' or bright patch.

**The Mean Centre** of the Moon, or intersection of lunar meridian 0° with the lunar equator, can always be readily found, as it is approximately the point equidistant from the three craters, Herschel, Schröter, and Triesnecker. The lunar equator is very nearly the line drawn through Rhaeticus and Landsberg; and lunar longitude 0°, a line drawn through the centre of Walter and the east side of Aristillus.

**Index, Map of the Moon.** The diameters, given in miles, are approximate, as authorities sometimes differ, owing to irregular shape, &c. The letters Bc, Bb, &c. indicate the square in which the object will be found.

	Diam.		Diam.		Diam.		Diam.		Diam.
Agrippa	Bc 27 <sup>m</sup>	Copernicus	Cc 56 <sup>m</sup>	Hell	Ca 18 <sup>m</sup>	Messier†	Ab 9 <sup>m</sup>	Schillert†	Ca 113
Albategniust	Bb 64	Crüger	Db 30	Hercules	Bd 46	Moretus†	Ca 78	Schröter	Cc 25
Alpetragius	Cb 27	Cyrillust	Bb 65	Herschel	Cb 24			Stadius	Cc 43
Alphonsust	Cb 83			Hervelt	Dc 71	Otto Struvet	Dc 150	Stöflert†	Ba 150
Anaximander	Cd 39	Delambre	Bb 32	Hippalust	Cb 38				
Apollonius	Ac 30	Delisle	Cc 16	Hipparchust	Bb 92	Parry†	Cb 25	Taruntius	Ac 44
Archimedes	Cc 50			Hyginus & Cleft	Bc 4	Petaviust	Ab 100	Thebit	Cb 32
Aristarchus	Dc 28	Encke	Dc 20			Philolaus	Cd 46	Theophilus	Bb 64
Aristillus	Bd 34	Endymion†	Bd 78	Kepler	Dc 22	Piazzi†	Da 90	Timocharis	Cc 23
Aristoteles	Bd 51	Eratosthenes	Cc 38			Picard	Ac 21	Triesnecker	Bc 14
Arzachel	Cb 66	Euclides†	Cb 7	Lambert	Cc 18	Piccolomini	Bb 57	Tycho	Ca 54
Atlas	Bd 55	Eudoxus	Bd 40	Landsberg	Cb 28	Pitatus†	Cb 58		
Autolyceus	Bd 23	Euler	Cc 19	Langrenust	Ab 90	Platot	Cd 60	Vendelinust	Ab 90
				Letronne	Db 50	Plinius	Bc 32	Vieta	Db 51
Bailly†	Ca 149	Fabricius	Ba 55	Lindenau	Ba 35	Posidonius†	Bd 62	Vitello	Db 28
Bessel†	Bc 14	Flamsteed	Db 9	Linné†	Bc 2	Proclus	Ac 18	Vitruvius	Bc 19
Blancanus	Ca 51	Fracastorius†	Ab 60	Longomontanus†	Ca 90	Ptolemæust	Cb 115	Vlacq	Ba 57
Bullialdus	Cb 38	Furnerius†	Aa 80			Purbacht†	Cb 60		
Burg	Bd 28			Macrobius	Ac 42			Walter†	Ba 100
Byrgius	Db 40	Gambart	Cc 16	Maginust	Ca 100	Reiner	Dc 21	Werner	Bb 45
		Gassendi†	Db 55	Mairan	Dd 25	Reinhold	Cc 31	Wilhelm I.†	Ca 46
Capella	Ab 30	Gausst	Ad 111	Manilius	Bc 25	Rhaeticus	Bc 25	Wurzelbauer†	Ca 50
Capuanus	Ca 34	Godin	Bc 23	Marius	Dc 27	Riccioli†	Db 106		
Cassini	Bd 36	Grimaldit	Db 147	Maskelyne	Bc 19	Römer	Ac 24	Zach	Ba 46
Catharinat	Bb 70			Maurolycust	Ba 150				
Claviust	Ca 142	Hainzelt	Ca 55	Mersenius	Db 41	Santbech	Ab 46		
Cleomedest	Ac 78	Helicon	Cd 13	Messala†	Ad 69	Schickard†	Da 134		

(as seen in an inverting Telescope).

(as seen in an inverting Telescope).



## LUNAR MOUNTAINS

Height, ft.		Height, ft.	
Alps, Bd	12,000	Dœrfel Mts. Ca	26,000
Alpine Valley Bd	...	Hæmus Mt. Bc	8,700
Altai Mts. Bb	13,000	Leibnitz Mts. Ba	30,000
Apennines Cc	18,500	Pyreneæ Ab	12,000
Bradley, Mt. Bc	13,600	Riphean Mts. Cb	2,700
Caucasus Bd	18,500	Taurus Mt. Ad	10,000

LUNAR SEAS (OR 'MARIA'), &c.

Mare Australe ... Aa	Mare Nectaris ... Ab	Lacus Somniorum	Bd
„ Crisium ... Ac	„ Nubium ... Cb	Palus Nebularum	Bd
„ Fœcunditatis Ab	„ Serenitatis ... Bc	„ Somnii ... ..	Ac
„ Frigoris ... Bd	„ Tranquillitatis Ac	Sinus Aestuum ...	Cc
„ Humboldtianum Ad	„ Vaporum ... Bc	„ Iridum ... ..	Cd
„ Humorum ... Db	Ocean. Procellarum De	„ Medii ... ..	Cc
„ Imbrium ... Cd	Lacus Mortis ... Bd	„ Roris ... ..	Dd

# MAGNITUDES AND RELATIVE BRIGHTNESS OF PLANETS, STARS, &c.

Compared with a standard 1st magnitude star. The star magnitudes only are from the Revised Harvard Photometry.

Name of Star, &c.	H.R. Mag.	App. Brightness, 109,650 millions	Name of Star.	H.R. Mag.	Approx. Relative Brightness.	Name of Star.	H.R. Mag.	Approx. Relative Brightness.	Name of Star.	H.R. Mag.	Approx. Relative Brightness.
Sun ...	-26.6		Achernar ...	0.60	1.45	γ Crucis ...	1.60	0.58	ε Sagittarii...	1.95	0.42
Moon (Full) -12.2		190,550	β Centauri ...	0.86	1.14	ε Canis Maj.	1.63	0.56	α Ursæ Maj.	1.95	0.42
Venus... ..-4.28		129.4	Altair ... ..	0.89	1.11	ε Ursæ Maj.	1.68	0.53	δ Canis Maj.	1.98	0.41
Jupiter* ...-2.52		25.59	Betelgeuse ...	0.92	1.08	γ Orionis ...	1.70	0.52	β Canis Maj.	1.99	0.40
Mars* ... ..-2.25		19.95	Magnitude	1.00	1.00	α <sup>2</sup> Centauri ...	1.70	0.52	Magnitude	2.00	0.40
Mercury (Max) -1.8		13.18	Aldebaran ...	1.06	0.95	λ Scorpionis	1.71	0.52	Polaris ... ..	2.12	0.36
Sirius ... ..-1.58		10.77	Spica ... ..	1.21	0.82	ε Carinæ ...	1.74	0.51	Magnitude	2.50	0.25
Saturn* ... ..-0.93		5.92	Pollux ... ..	1.21	0.82	ε Orionis ...	1.75	0.50	" ... ..	3.00	0.16
Canopus ... ..-0.86		5.55	Antares ... ..	1.22	0.82	β Tauri ... ..	1.78	0.49	" ... ..	3.50	0.10
Magnitude 0.00		2.51	Fomalhaut ...	1.29	0.77	β Carinæ ...	1.80	0.48	" ... ..	4.00	0.06
Vega ... ..	0.14	2.21	Arided ... ..	1.33	0.74	α Triang. Aust.	1.88	0.44	" ... ..	4.50	0.04
Capella ... ..	0.21	2.07	Regulus... ..	1.34	0.73	α Persei ...	1.90	0.44	" ... ..	5.00	0.03
Arcturus ...	0.24	2.01	β Crucis ...	1.50	0.63	η Ursæ Maj.	1.91	0.43	" ... ..	5.50	0.02
α <sup>1</sup> Centauri	0.33	1.85	α <sup>1</sup> Crucis ...	1.58	0.59	ζ Orionis ...	1.91	0.43	" ... ..	6.00	0.01
Rigel ... ..	0.34	1.84	Castor ... ..	1.58	0.59	γ Geminorum	1.93	0.42	" ... ..	6.50	0.006
Procyon ...	0.48	1.61									

\* Mean opposition magnitudes.

## DATE WHEN THE CENTRAL MERIDIAN OF EACH MAP IS ON THE MERIDIAN.

Central Meridian		APPROX. DATE WHEN ON THE MERIDIAN—i.e. on the line due north and south.					
No. of Map.	Central Meridian	At 8 p.m.	At 10 p.m.	At Midnight.	At 2 a.m.	At 4 a.m.	
Maps 3 and 4	XXIV hrs.	Nov. 21	Oct. 22	Sept. 21	Aug. 22	July 22	
" 5 " 6	IV "	Jan. 21	Dec. 21	Nov. 21	Oct. 22	Sept. 21	
" 7 " 8	VIII "	March 23	Feb. 20	Jan. 21	Dec. 21	Nov. 21	
" 9 " 10	XII "	May 22	April 22	March 22	Feb. 20	Jan. 21	
" 11 " 12	XVI "	July 22	June 22	May 22	April 22	March 22	
" 13 " 14	XX "	Sept. 21	Aug. 22	July 22	June 22	May 22	

Examples.—(1) When will the constellation Taurus be south at 10 p.m.? From the Index of Constellations we find that Taurus is in Map 5. On referring to the above table, opposite Map 5, in the column headed 10 p.m., we learn that the date will be December 21.

(2) What constellations are in the south at 8 p.m. on March 23? We find the date, March 23, in the column headed 8 p.m., and see that Maps 7 & 8 are then south, containing Gemini, Cancer, Hydra, &c.

## THE GREEK ALPHABET.

Letter.	Name.	Letter.	Name.	Letter.	Name.	Letter.	Name.	Letter.	Name.	Letter.	Name.
α .....	Alpha	ε .....	Epsilon	ι .....	Iota	ν .....	Nu	ρ .....	Rho	φ .....	Phi
β .....	Beta	ζ .....	Zeta	κ .....	Kappa	ξ .....	Xi	σ .....	Sigma	χ .....	Chi
γ .....	Gamma	η .....	Eta	λ .....	Lambda	ο .....	Omicron	τ .....	Tau	ψ .....	Psi
δ .....	Delta	θ .....	Theta	μ .....	Mu	π .....	Pi	υ .....	Upsilon	ω .....	Omega

## THE HOUR OF RIGHT ASCENSION ON THE MERIDIAN AT 9 P.M.

Or Sidereal Time at 9 p.m. For each hour earlier, subtract one hour of R.A. ; for each hour later, add one hour of R.A.

Date.	Right Ascension at 9 p.m.	Date.	Right Ascension at 9 p.m.	Date.	Right Ascension at 9 p.m.	Date.	Right Ascension at 9 p.m.	Date.	Right Ascension at 9 p.m.	Date.	Right Ascension at 9 p.m.
Jan. 1	h. m. III 40	Mar. 2	h. m. VII 40	May 2	h. m. XI 40	July 2	h. m. XV 40	Sept. 1	h. m. XIX 40	Nov. 1	h. m. XXIII 40
" 5	IV 0	" 7	VIII 0	" 7	XII 0	" 7	XVI 0	" 6	XX 0	" 6	XXIV 0
" 10	" 20	" 12	" 20	" 12	" 20	" 12	" 20	" 11	" 20	" 11	" 20
" 13	" 30	" 15	" 30	" 15	" 30	" 15	" 30	" 14	" 30	" 13	" 30
" 16	" 40	" 17	" 40	" 17	" 40	" 17	" 40	" 16	" 40	" 16	" 40
" 21	V 0	" 23	IX 0	" 22	XIII 0	" 22	XVII 0	" 21	XXI 0	" 21	I h. 0
" 26	" 20	" 28	" 20	" 27	" 20	" 27	" 20	" 26	" 20	" 26	" 20
" 28	" 30	" 30	" 30	" 30	" 30	" 30	" 30	" 29	" 30	" 29	" 30
" 31	" 40	Apr. 2	" 40	June 2	" 40	Aug. 1	" 40	Oct. 1	" 40	Dec. 1	" 40
Feb. 5	VI 0	" 7	X 0	" 7	XIV 0	" 6	XVIII 0	" 6	XXII 0	" 6	II 0
" 10	" 20	" 12	" 20	" 12	" 20	" 12	" 20	" 12	" 20	" 11	" 20
" 12	" 30	" 14	" 30	" 14	" 30	" 14	" 30	" 14	" 30	" 14	" 30
" 15	" 40	" 17	" 40	" 17	" 40	" 17	" 40	" 17	" 40	" 16	" 40
" 20	VII 0	" 22	XI 0	" 22	XV 0	" 22	XIX 0	" 22	XXIII 0	" 21	III 0
" 25	" 20	" 27	" 20	" 27	" 20	" 27	" 20	" 27	" 20	" 27	" 20
Feb. 28	VII 30	Apr. 30	XI 30	June 29	XV 30	Aug. 29	XIX 30	Oct. 29	XXIII 30	Dec. 29	III 30

# LIST OF STAR NAMES.

Name.	=	Name.	=	Name.	=
<i>Achernar</i> ... ..	<i>a</i> Eridani.	<i>Cor Scorpionis</i> ( <i>Antares</i> ) <i>a</i> Scorpionis.		<i>Muphrid</i> ... ..	<i>η</i> Bootis.
<i>Acrab, Akrab</i> ... ..	<i>β</i> Scorpionis.	<i>Cor Serpentis</i> ( <i>Unukalhay</i> ) <i>a</i> Serpentis		<i>Nath</i> ... ..	<i>β</i> Tauri.
<i>Adara</i> ... ..	<i>ε</i> Canis Majoris.	<i>Cursa, Kursa</i> ... ..	<i>β</i> Eridani.	<i>Nekkar</i> ... ..	<i>β</i> Boötis.
<i>Albireo</i> ... ..	<i>β</i> Cygni.	<i>Deneb, Deneb Aleet,</i>	<i>β</i> Leonis.	<i>Okda</i> ( <i>Kaitain</i> ) ... ..	<i>a</i> Piscium.
<i>Alchiba, Al-khiba</i> ... ..	<i>a</i> Corvi.	<i>Denebola</i> ... ..		<i>Phakt, Phact</i> ... ..	<i>a</i> Columbæ.
<i>Alcor</i> ... ..	80 <i>Ursæ Majoris</i> .	<i>Deneb Algiedi</i> ... ..	<i>δ</i> Capricorni.	<i>Phecda, Phekha</i> ... ..	<i>γ</i> <i>Ursæ Majoris</i> .
<i>Alcyone</i> ( <i>a</i> Pleiad) ... ..	<i>η</i> Tauri.	<i>Deneb, Deneb el Adige</i>	<i>a</i> Cygni.	<i>Pleione</i> ( <i>a</i> Pleiad) ... ..	28 <i>Tauri</i> .
<i>Aldebaran</i> ... ..	<i>a</i> Tauri.	( <i>Arided</i> ) ... ..		<i>Polaris</i> ... ..	<i>a</i> <i>Ursæ Minoris</i> .
<i>Alderamin</i> ... ..	<i>a</i> Cephei.	<i>Deneb Kaitos shemali</i> ... ..	<i>ι</i> Ceti.	<i>Pollux</i> ... ..	<i>β</i> Geminorum.
<i>Algeiba, Algieba</i> ... ..	<i>γ</i> Leonis.	<i>Diphda</i> ( <i>Deneb Kaitos jenubi</i> ) <i>β</i> Ceti.		<i>Prima Giedi</i> ... ..	<i>a</i> <sup>1</sup> <i>Capricorni</i> .
<i>Algenib</i> ... ..	<i>γ</i> Pegasi.	<i>Dubhe</i> ... ..	<i>a</i> <i>Ursæ Majoris</i> .	<i>Procyon</i> ... ..	<i>a</i> <i>Canis Minoris</i> .
<i>Algol</i> ... ..	<i>β</i> Persei.	<i>Electra</i> ( <i>a</i> Pleiad) ... ..	17 <i>Tauri</i> .	<i>Pulcherrima</i> ... ..	<i>ε</i> Boötis.
<i>Algorab, Algorel, Algores</i> ... ..	<i>δ</i> Corvi.	<i>Enif, Eniph</i> ( <i>Fom</i> ) ... ..	<i>ε</i> Pegasi.	<i>Ras Algethi, Rasalegti</i> ... ..	<i>a</i> Herculis.
<i>Alhena</i> ... ..	<i>γ</i> Geminorum.	<i>Errai</i> ( <i>Alrai</i> ) ... ..	<i>γ</i> Cephei.	<i>Ras Alhagua, Ras-al-hague</i> <i>a</i> Ophiuchi.	
<i>Alioth</i> ... ..	<i>ε</i> <i>Ursæ Majoris</i> .	<i>Etamin, Etanin</i> ... ..	<i>γ</i> Draconis.	<i>Rastaban, Rasaben</i> ... ..	<i>γ</i> Draconis.
<i>Alkaid</i> ( <i>Benetnasch</i> ) <i>η</i> <i>Ursæ Majoris</i> .		<i>Fom</i> ( <i>Enif</i> ) ... ..	<i>ε</i> Pegasi.	<i>Regulus</i> ( <i>Cor Leonis</i> ) ... ..	<i>a</i> Leonis.
<i>Alkalurops</i> ... ..	<i>μ</i> <sup>1</sup> Boötis.	<i>Fomalhaut</i> ... ..	<i>a</i> <i>Piscis Australis</i> .	<i>Rigel</i> ... ..	<i>β</i> Orionis.
<i>Alkes</i> ... ..	<i>a</i> Crateris.	<i>Gemma</i> ... ..	<i>a</i> <i>Coronæ Borealis</i> .	<i>Rotanev</i> ... ..	<i>β</i> Delphini.
<i>Almak, Almach</i> ... ..	<i>γ</i> Andromedæ.	<i>Giedi</i> ... ..	<i>a</i> <i>Capricorni</i> .	<i>Sadachbia</i> ... ..	<i>γ</i> Aquarii.
<i>Alnilam</i> ... ..	<i>ε</i> Orionis.	<i>Gomeisa</i> ... ..	<i>β</i> <i>Canis Minoris</i> .	<i>Sadalmelik, Sadalmulk</i> ... ..	<i>a</i> Aquarii.
<i>Alphard</i> ( <i>Cor Hydræ</i> ) ... ..	<i>a</i> Hydræ.	<i>Hamal</i> ... ..	<i>a</i> Arietis.	<i>Sadalsud, Sadalsund</i> ... ..	<i>β</i> Aquarii.
<i>Alphecca, Alphekka</i> <i>a</i> <i>Coronæ Borealis</i> .		<i>Homam, Homan</i> ... ..	<i>ζ</i> Pegasi.	<i>Secunda Giedi</i> ... ..	<i>a</i> <sup>2</sup> <i>Capricorni</i> .
<i>Alpheratz, Alpherat</i>	<i>a</i> Andromedæ.	<i>Izar</i> ( <i>Mizar, Mirac</i> ) ... ..	<i>ε</i> Boötis.	<i>Scheat, Sheat</i> ... ..	<i>β</i> Pegasi.
( <i>Sirrah</i> )		<i>Kaitain</i> ( <i>Okda</i> ) ... ..	<i>a</i> Piscium.	<i>Schedir, Shedir, Schedar</i> <i>a</i> Cassiopeiæ.	
<i>Alphirk</i> ... ..	<i>β</i> Cephei.	<i>Kaus Australis</i> ... ..	<i>ε</i> Sagittarii.	<i>Sheliak</i> ... ..	<i>β</i> Lyrae.
<i>Alrai</i> ( <i>Errai</i> ) ... ..	<i>γ</i> Cephei.	<i>Keid</i> ... ..	40 <i>Eridani</i> .	<i>Sheratan, Sharatain</i> ... ..	<i>β</i> Arietis.
<i>Alruccabah</i> ( <i>Polaris</i> ) <i>a</i> <i>Ursæ Minoris</i> .		<i>Kelb al Rai, Celb al Rai</i> <i>β</i> Ophiuchi.		<i>Sirius</i> ... ..	<i>a</i> <i>Canis Majoris</i> .
<i>Alshain, Alshairn</i> ... ..	<i>β</i> Aquilæ.	<i>Kocab, Kochab</i> ... ..	<i>β</i> <i>Ursæ Minoris</i> .	<i>Sirrah</i> ( <i>Alpheratz</i> ) ... ..	<i>a</i> Andromedæ.
<i>Altair</i> ... ..	<i>a</i> Aquilæ.	<i>Kornephoros</i> ... ..	<i>β</i> Herculis.	<i>Skat, Sheat, Scheat</i> ... ..	<i>δ</i> Aquarii.
<i>Alwaid</i> ... ..	<i>β</i> Draconis.	<i>Kursa, Cursa</i> ... ..	<i>β</i> Eridani.	<i>Spica</i> ... ..	<i>a</i> Virginis.
<i>Antares</i> ( <i>Cor Scorpionis</i> ) <i>a</i> Scorpionis.		<i>Maia</i> ( <i>a</i> Pleiad) ... ..	20 <i>Tauri</i> .	<i>Sulaphat</i> ... ..	<i>γ</i> Lyrae.
<i>Arcturus</i> ... ..	<i>a</i> Boötis.	<i>Markab</i> ... ..	<i>a</i> Pegasi.	<i>Svalocin</i> ... ..	<i>a</i> Delphini.
<i>Arided</i> ( <i>Deneb Adige</i> ) ... ..	<i>a</i> Cygni.	<i>Marsik</i> ... ..	<i>κ</i> Herculis.	<i>Talitha, Talita</i> ... ..	<i>ι</i> <i>Ursæ Majoris</i> .
<i>Arneb</i> ... ..	<i>a</i> Leporis.	<i>Mebstuta</i> ... ..	<i>ε</i> Geminorum.	<i>Tarazed</i> ... ..	<i>γ</i> Aquilæ.
<i>Asterope</i> ( <i>a</i> Pleiad) ... ..	21 <i>Tauri</i> .	<i>Megrez</i> ... ..	<i>δ</i> <i>Ursæ Majoris</i> .	<i>Taygeta</i> ( <i>a</i> Pleiad) ... ..	19 <i>Tauri</i> .
<i>Atlas</i> ( <i>a</i> Pleiad) ... ..	27 <i>Tauri</i> .	<i>Mekab, Menkab, Menkar</i> ... ..	<i>a</i> Ceti.	<i>Thuban</i> ... ..	<i>a</i> Draconis.
<i>Azelfafage</i> ... ..	<i>π</i> <sup>1</sup> Cygni.	<i>Menkalinan</i> ... ..	<i>β</i> Aurigæ.	<i>Unukalhay</i> ( <i>Cor</i> }	<i>a</i> Serpentis.
<i>Azimech</i> ( <i>Spica</i> ) ... ..	<i>a</i> Virginis.	<i>Merak</i> ... ..	<i>β</i> <i>Ursæ Majoris</i> .	<i>Serpentis</i> )	
<i>Baten Kaitos</i> ... ..	<i>ζ</i> Ceti.	<i>Merope</i> ( <i>a</i> Pleiad) ... ..	23 <i>Tauri</i> .	<i>Vega, Wega</i> ... ..	<i>a</i> Lyrae.
<i>Bellatrix</i> ... ..	<i>γ</i> Orionis.	<i>Mesarthim, Mesartim</i> ... ..	<i>γ</i> Arietis.	<i>Vindemiatrix</i> ... ..	<i>ε</i> Virginis.
<i>Benetnasch</i> ... ..	<i>η</i> <i>Ursæ Majoris</i> .	<i>Mintaka</i> ... ..	<i>δ</i> Orionis.	<i>Wasat</i> ... ..	<i>δ</i> Geminorum.
<i>Betelgeux, Betelgeuze</i> ... ..	<i>a</i> Orionis.	<i>Mira</i> ... ..	<i>ο</i> Ceti.	<i>Yed</i> ... ..	<i>δ</i> Ophiuchi.
<i>Canopus</i> ... ..	<i>a</i> Argûs.	<i>Mirac, Mirach</i> ... ..	<i>β</i> Andromedæ.	<i>Zaurak</i> ... ..	<i>γ</i> <sup>1</sup> <i>Eridani</i> .
<i>Capella</i> ... ..	<i>a</i> Aurigæ.	<i>Mirac, Mirach</i> ( <i>Izar</i> ) ... ..	<i>ε</i> Boötis.	<i>Zawijah, Zavijava</i> ... ..	<i>β</i> Virginis.
<i>Caph, Chaph</i> ... ..	<i>β</i> Cassiopeiæ.	<i>Mirfak, Mirphak</i> ... ..	<i>a</i> Persei.	<i>Zosca, Zosma</i> ... ..	<i>δ</i> Leonis.
<i>Castor</i> ... ..	<i>a</i> Geminorum.	<i>Mirzam</i> ... ..	<i>β</i> <i>Canis Majoris</i> .	<i>Zuben el Genubi</i> ... ..	<i>a</i> Libræ.
<i>Cor Caroli</i> ... ..	<i>a</i> <i>Canum Venaticorum</i> .	<i>Mizar</i> ... ..	<i>β</i> Andromedæ.	<i>Zuben el Hakrabi</i> ... ..	<i>γ</i> Libræ.
<i>Cor Hydræ</i> ( <i>Alphard</i> ) ... ..	<i>a</i> Hydræ.	<i>Mizar</i> ... ..	<i>ε</i> Boötis.	<i>Zubenesch, Zuben el</i>	<i>β</i> Libræ.
<i>Cor Leonis</i> ( <i>Regulus</i> ) ... ..	<i>a</i> Leonis.	<i>Mizar</i> ... ..	<i>ζ</i> <i>Ursæ Majoris</i> .	<i>Chamali, Zubenelg</i>	

## TELESCOPIC OBJECTS—MAPS 1 & 2.

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### DOUBLE STARS.

- $\eta$  CASSIOPEÆ. 0h. 44m. N.  $57^{\circ} 25'$ . A binary star. Period 196 years. Magnitudes 4 and  $7\frac{1}{2}$ . Distance  $5\cdot7''$  (1903),  $6\cdot4''$  (1915). Colours, yellow and pale red.
- $\sigma$  CASSIOPEÆ. 23h. 55m. N.  $55^{\circ} 20'$ . A double star. Magnitudes  $5\frac{1}{2}$  and  $7\frac{1}{2}$ . Distance  $3''$ . A grand field with a low power.
- $\beta$  CEPHEI. 21h. 27m. N.  $70^{\circ} 15'$ . A 3rd mag. star with a bluish 8th mag. *comes*,  $14''$  distant.
- $\xi$  CEPHEI. 22h. 2m. N.  $64^{\circ} 15'$ . A double star. Mags. of components 5 and  $6\frac{1}{2}$ . Distance about  $7''$ .
- $\delta$  CEPHEI. 22h. 26m. N.  $58^{\circ} 0'$ . A fine double star. The brighter star varies from  $3\cdot7$  to 5 mag. in a period of 5d.  $8\frac{3}{4}$ h. The companion is a 5th mag. blue star,  $41''$  distant.
- $\nu$  DRACONIS. 17h. 30m. N.  $55^{\circ} 15'$ . A double star composed of two  $4\frac{1}{2}$  mag. stars. Distance  $62''$ .
- $\zeta$  URSE MAJORIS (*Mizar*). 13h. 20m. N.  $55^{\circ} 20'$ . The middle star of the Great Bear's tail. A splendid double star with components of the 2nd and 4th magnitudes and  $14''$  apart. It forms with 80 (*Alcor*), about  $11'$  distant, a naked-eye pair. Several fainter stars are included in a large field.
- $\alpha$  URSE MINORIS (*Polaris*). 1h. 32m. N.  $88^{\circ} 50'$ . The Polar Star. In 1920 it will be about  $1^{\circ} 7'$  from the north celestial pole, and in the year 2095 within  $26' 30''$ . It is a 2nd mag. star with a 9th mag. bluish attendant  $19''$  distant, a well known test for instruments of less than 3 in. aperture. Polaris can easily be found by means of the "Pointers,"  $\alpha$  and  $\beta$  Urse Majoris.
- $\pi^1$  URSE MINORIS. 15h. 34m. N.  $80^{\circ} 40'$ . A double star, north preceding  $\zeta$ . Components of the 6th and 7th mags. Distance  $30''$ .

### VARIABLE STARS.

- $\mu$  CEPHEI. 21h. 41m. N.  $58^{\circ} 25'$ . An irregular variable star "of a fine deep garnet colour." (Sir W. Herschel).
- NOVA CASSIOPEÆ. 0h. 20m. N.  $63^{\circ} 40'$ . The New Star of 1572 which equalled Venus in brilliancy and then died away. The place should be carefully watched for a possible reappearance.

### NEBULÆ & STAR CLUSTERS.

- H. VI. 30 CASSIOPEÆ. 23h. 53m. N.  $56^{\circ} 15'$ . A beautiful cluster of small stars. Grand neighbouring fields.
- M. 52 CEPHEI. 23h. 21m. N.  $61^{\circ} 10'$ . An irregular cluster containing an orange-coloured star.
- H. IV. 37. DRACONIS. 17h. 59m. N.  $66^{\circ} 35'$ . A remarkable, bluish, elliptic, planetary nebula. It lies near the N. Pole of the Ecliptic, between the Polar Star and  $\gamma$  Draconis.
- M. 97. URSE MAJORIS. 11h. 10m. N.  $55^{\circ} 30'$ . A large, remarkable, planetary nebula with a faint disc, of the apparent diameter of Jupiter. The "Owl Nebula" of Lord Rosse: so called from its appearance in his great reflector.

**MAPS 1 AND 2**  
*(Circumpolar, North)*



B.A.C. British Association number.  
 β Burnham's number.  
 Br. Brisbane's number.  
 Δ Dunlop's number.  
 E.S. Espin and Birmingham's number.  
 H Sir W. Herschel's number.  
 h Sir J. Herschel's number.  
 Jac. Jacob's number.  
 Lac. Lacaille's number.  
 L. Lande's number.  
 M. Messier's nebula number;  
 OZ Otto Struve's number.  
 OZZ Pulkova Cat. Pt. II, No.  
 R or Ru. (small, to star)  
     - Ruddy or yellow star.  
 Rus. Russell's number.  
 Sa. Santiago number.  
 St. Stie's number.  
 S.F. Struve's number.  
 S. Do. Appendix d.  
 V or Var. (small, to star)  
     - Variable star.

**MAGNITUDES**

	<b>1</b>
	<b>2</b>
	<b>3</b>
	<b>4</b>
	<b>5</b>
	<b>6</b>
	<b>NEBULA</b>

## TELESCOPIC OBJECTS—MAPS 3 & 4.

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### DOUBLE STARS.

- $\pi$  ANDROMEDÆ. 0h. 32m. N.  $33^{\circ} 15'$ . A double star. Components of the 4th and 8th mags. Distance  $36''$ .
- $\gamma$  ANDROMEDÆ. 1h. 59m. N.  $41^{\circ} 55'$ . A magnificent binary star, period 55 yrs.: an orange 3rd mag. star with a blue 5th mag.,  $10''$  distant. The smaller star is a very close double. 1889, almost closed; 1902,  $0.25''$ ; 1916,  $0.65''$ .
- 41 AQUARI. 22h. 10m. S.  $21^{\circ} 30'$ . A double star consisting of a reddish 6th. mag. star with a blue 8th mag.,  $5''$  distant.
- $\zeta$  AQUARI. 22h. 25m. S.  $0^{\circ} 25'$ . A very fine object in a small telescope. Its distance of  $4.5''$  in 1780 had closed to  $3''$  in 1892.  $2.8''$  (1915). Magnitudes 4 and 4.1. A binary star.
- $\psi^1$  AQUARI. 23h. 12m. S.  $9^{\circ} 30'$ . A wide double star ( $50''$ ). The brighter star is of mag.  $4\frac{1}{2}$ , and yellow; the other  $8\frac{1}{2}$  mag., and blue.
- 8 LACERTÆ. 22h. 32m. N.  $39^{\circ} 10'$ . A quadruple star, whose components are of the mags. 6,  $6\frac{1}{2}$ , 10 and 9.
- $\epsilon$  PEGASI. 21h. 40m. N.  $9^{\circ} 30'$ . A triple star, but only a wide double in small telescopes. Magnitudes  $2\frac{1}{2}$  and 9. Distance  $140''$ .
- $\pi^1$  PEGASI. 22h. 6m. N.  $32^{\circ} 45'$ . Forms with  $\pi^2$  a fine wide pair.
- $\eta$  PEGASI. 22h. 40m. N.  $29^{\circ} 45'$ . A 3rd mag. star with a 10th mag. companion,  $90''$  distant. A test for a 3-inch telescope.
- 35 PISCUM. 0h. 11m. N.  $8^{\circ} 20'$ . A double star. The components are of about the 6th and 7th mags. Distance  $11.5''$ .
- $\epsilon$  TRIANGULI. 2h. 8m. N.  $29^{\circ} 55'$ . A lovely double star. Its components are of mags. 5 and  $6\frac{1}{2}$ . Distance  $3.6''$ .

### VARIABLE STAR.

- $\alpha$  CETI (*Mira*). 2h. 15m. S.  $3^{\circ} 20'$ . A wonderful irregular variable star, which changes from  $1\frac{1}{2}$  to  $9\frac{1}{2}$  magnitude.

### NEBULÆ & STAR CLUSTERS.

- M. 31 ANDROMEDÆ. 0h. 38m. N.  $40^{\circ} 50'$ . The Great Nebula. Visible to the naked eye, preceding  $\nu$ . In small telescopes, an oval, hazy mass. Photographs show it as a wonderful spiral.
- H. VIII. 75, LACERTÆ. 22h. 12m. N.  $49^{\circ} 30'$ . A fine cluster, with a beautiful field following it.

**MAPS 3 AND 4**  
(R.A. XXII hrs. to II hrs.)



MAP 3

ANNO 1920.

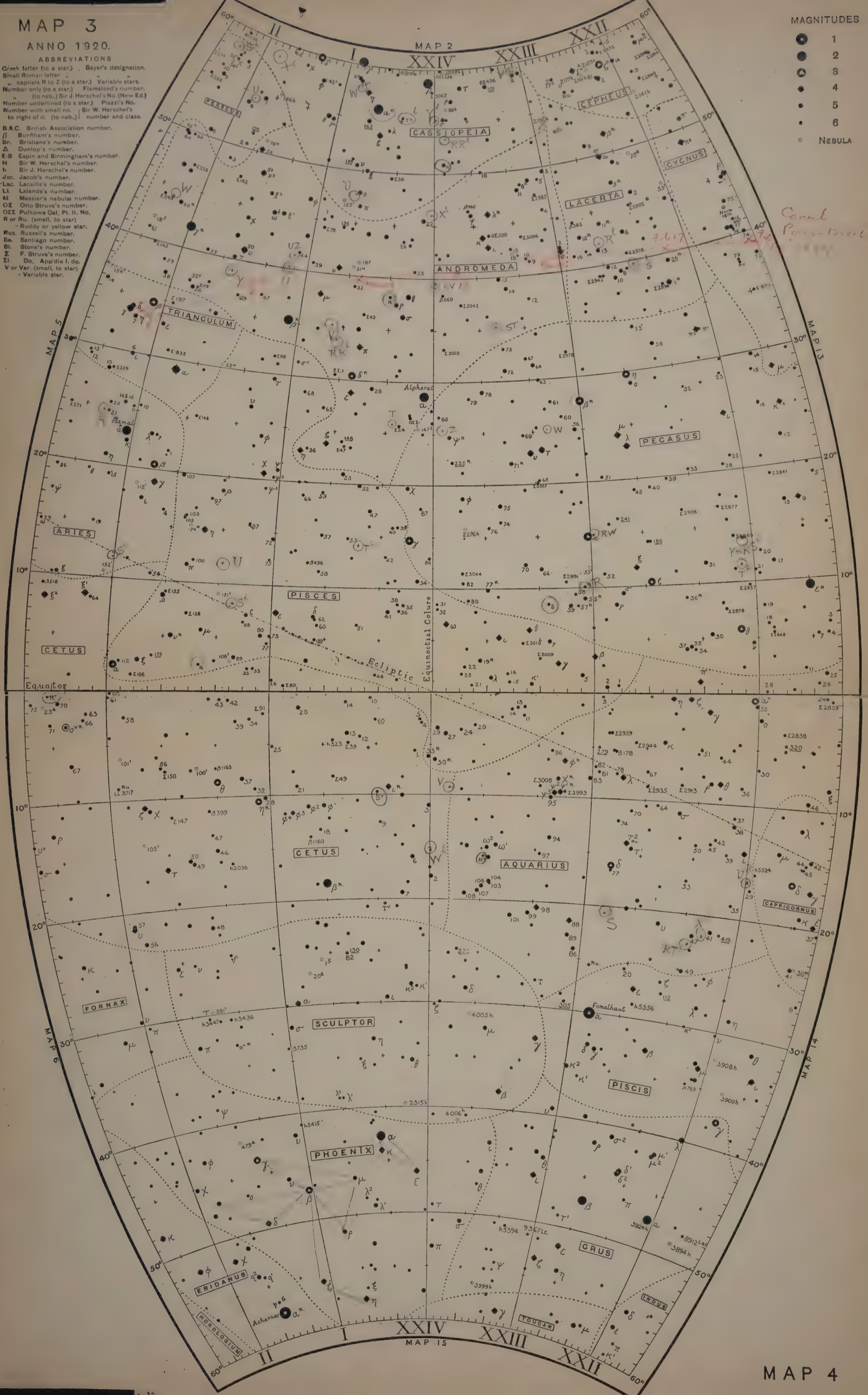
ABBREVIATIONS

Greek letter (to a star) . Bayer's designation.  
Small Roman letter . . . . .  
Capital R to Z (to a star) . . . . .  
Number only (to a star) . . . . .  
(to neb.) Sir J. Herschel's No. (New Ed.)  
Number underlined (to a star) . . . . .  
Number with small no. . . . .  
to right of it. (to neb.) . . . . .  
B.A.C. British Association number.  
β Burdham's number.  
Br. Brisbane's number.  
Δ Dunlop's number.  
E.B. Eschin and Birmingham's number.  
H. Sir W. Herschel's number.  
h. Sir J. Herschel's number.  
Jac. Jacob's number.  
Lac. Lacaille's number.  
L.L. Lalande's number.  
M. Messier's nebula number.  
O.Z. Otto Struve's number.  
O.Z.I. Pulkova Cat. Pt. II. No.  
R or Ru. (small, to star)  
- Ruddy or yellow star.  
Rus. Russell's number.  
Sa. Santiago number.  
St. Stone's number.  
Σ. F. Struve's number.  
Do. Appendix I. do.  
ΣI. Var. (small, to star)  
V or Var. (small, to star)  
- Variable star.

MAGNITUDES

1
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NEBULA



## TELESCOPIC OBJECTS—MAPS 5 & 6.

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### DOUBLE STARS.

- $\gamma$  ARIETIS. 1h. 49m. N.  $18^{\circ} 55'$ . A double star discovered by Hooke in 1664. Magnitudes of each component,  $4\frac{1}{2}$ . Distance  $8.6''$ . A fine object.
- $\gamma$  CETI. 2h. 39m. N.  $2^{\circ} 50'$ . A 3rd mag. yellowish star with a 7th mag. companion. Distance  $2.6''$ .
- 32 ERIDANI. 3h. 50m. S.  $3^{\circ} 10'$ . A double star. The brighter component is of the 4th mag., and yellow: the fainter 6th mag., and blue or green. Distance  $6.7''$ .
- $\gamma$  LEPORIS. 5h. 41m. S.  $22^{\circ} 30'$ . A triple star. The chief components are of mags. 4 and  $6\frac{1}{2}$ , and  $93''$  distant. A third faint star is  $45''$  from the  $6\frac{1}{2}$  mag.
- $\beta$  ORIONIS (*Rigel*). 5h. 11m. S.  $8^{\circ} 20'$ . A star of the 1st mag. with a bluish 8th mag. attendant,  $9''$  distant. Well seen in  $2\frac{1}{4}$ -inch Wray.
- $\epsilon$  ORIONIS. 5h. 31m. S.  $5^{\circ} 55'$ . A double star. Magnitudes 3 and 7. Distance  $11''$ .
- $\sigma$  ORIONIS. 5h. 34m. S.  $2^{\circ} 40'$ . A multiple star. The chief components are of the magnitudes 4, 10,  $7\frac{1}{2}$ , and 7.
- 52 ORIONIS. 5h. 44m. N.  $6^{\circ} 25'$ . A double star, consisting of two equal 6 mag. stars at  $1.5''$  distance (1906). A hard test for 3 in.
- $\eta$  PERSEI. 2h. 44m. N.  $55^{\circ} 35'$ . A yellow 4th mag. star, with a blue attendant of  $8\frac{1}{2}$  mag. Distance  $28''$ .
- $\alpha$  TAURI (*Aldebaran*). 4h. 31m. N.  $16^{\circ} 20'$ . A star of the 1st mag. with an 11th mag. attendant,  $109''$  distant. A good light-test for a 3 in. telescope.

### VARIABLE STARS.

- $\beta$  PERSEI (*Algol*). 3h. 3m. N.  $40^{\circ} 40'$ . The Demon Star. This notable variable has a period of 2d. 20h. 49m. Its usual magnitude for about  $2\frac{1}{2}$  days is  $2\frac{1}{2}$ . In nearly  $3\frac{1}{2}$  hrs. it decreases to 3.6 mag., and after remaining at that for 18 or 20 minutes, in another  $3\frac{1}{2}$  hrs. it regains its former brilliancy.

### NEBULÆ & STAR CLUSTERS.

- M. 38. AURIGÆ. 5h. 23m. N.  $35^{\circ} 45'$ . A grand cluster in a splendid neighbourhood.
- M. 37. AURIGÆ. 5h. 47m. N.  $32^{\circ} 30'$ . An extremely beautiful cluster of about 500 stars.
- M. 42 ORIONIS. 5h. 31m. S.  $5^{\circ} 27'$ . "The Great Nebula in Orion," visible to the naked eye, is a fine object even in small telescopes. In its brightest part are four stars of 6, 7,  $7\frac{1}{2}$ , and 8 mags., which form the well-known "trapezium." Two other stars have been glimpsed here in a 3-inch telescope.
- H. VI. 33, 34. 2h. 15m. N.  $56^{\circ} 45'$ . The Cluster in the Sword Handle of Perseus. Two magnificent clusters, in the same field with a low power.
- M. 1 TAURI. 5h. 30m. N.  $22^{\circ} 0'$ . This nebula was discovered in 1731, forgotten, and rediscovered by Messier in 1758. The discovery led him to make his catalogue of 103 nebulae. The "Crab Nebula" of Lord Rosse.
- THE PLEIADES. A beautiful naked-eye cluster of 6 or 7 stars, though some have made out 14, and even 16, without optical aid. *Alcyone* is the brightest star, 3rd mag. A very low power with a wide field should be used.

**MAPS 5 AND 6**  
(R.A. 11 hrs. to VI hrs.)



ANNO 1920.

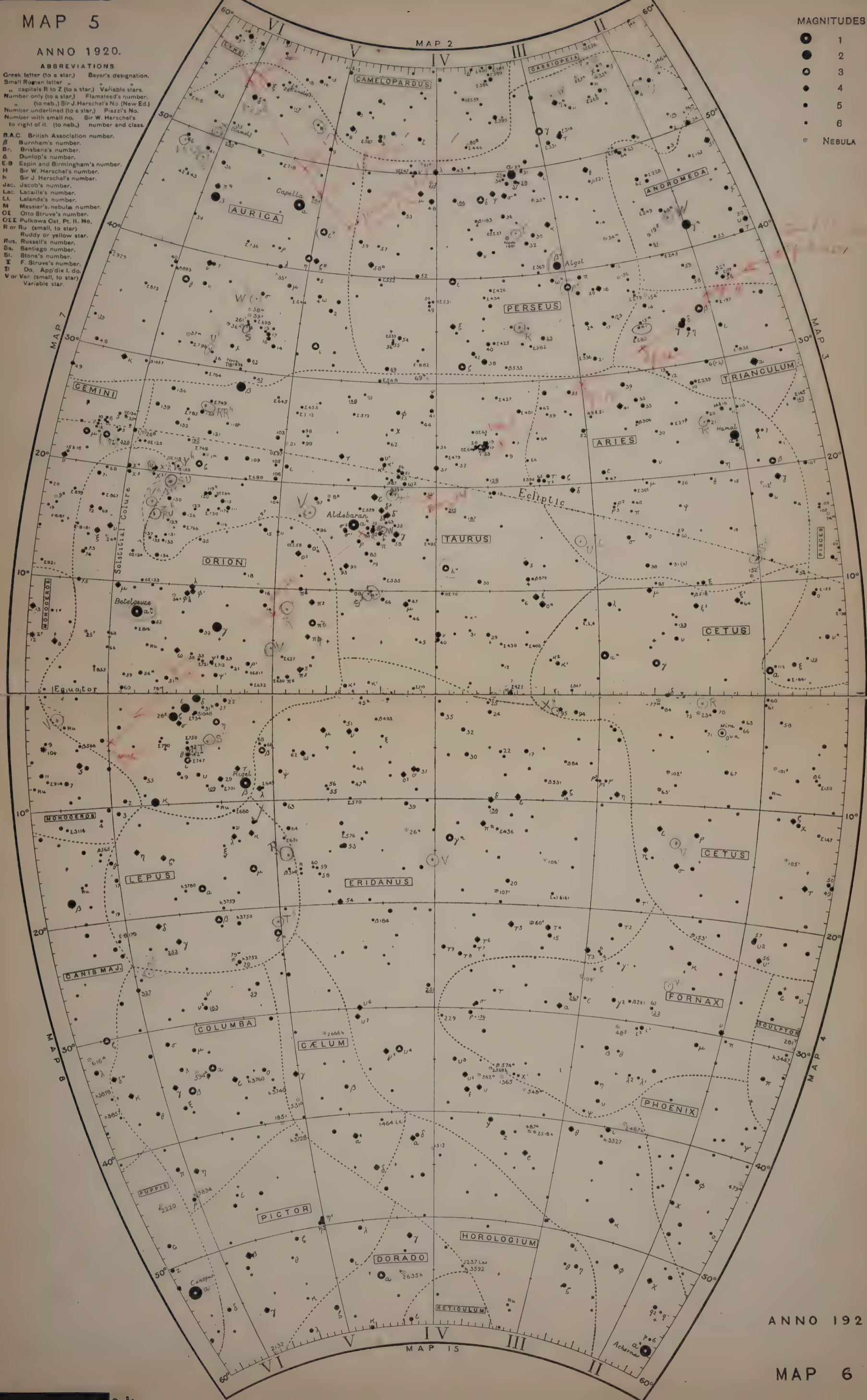
## ABBREVIATIONS

Greek letter (to a star.) Bayer's designation.  
 Small Roman letter. Variable stars.  
 Capital R to Z (to a star.) Flamsteed's number.  
 (to neb.) Sir J. Herschel's No. (New Ed.)  
 Number underlined (to a star.) Piazzi's No.  
 Number with small no. Sir W. Herschel's  
 to right of it. (to neb.) number and class.  
 B.A.C. British Association number.  
 B. Burnham's number.  
 Br. Brisbane's number.  
 D. Dunlop's number.  
 E.B. Espin and Birmingham's number.  
 H. Sir W. Herschel's number.  
 J. Jacob's number.  
 Lac. Lacaille's number.  
 L.L. Lalande's number.  
 M. Messier's nebula number.  
 O.E. Otto Struve's number.  
 O.E. Pulkowa Cat. Pt. II. No.  
 R or Ru (small, to star).  
 Ruddy or yellow star.  
 Rus. Russell's number.  
 Sa. Santiago number.  
 St. Stone's number.  
 T. F. Struve's number.  
 Do. Appendix I. do.  
 V or Var. (small, to star).  
 Variable star.

MAGNITUDES

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- 2
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- 5
- 6

NEBULA



ANNO 1920

## TELESCOPIC OBJECTS—MAPS 7 & 8.

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### DOUBLE & MULTIPLE STARS.

- h 273. ARGÛS. 7h. 35m. S.  $26^{\circ} 35'$ . A double star. Two 4th mag. stars at a distance of  $10''$ .
- 5 ARGÛS. 7h. 44m. S.  $12^{\circ} 0'$ . A double star. The magnitudes of the components are  $5\frac{1}{2}$  and  $7\frac{1}{2}$ , and their distance  $3\cdot3''$ .
- ζ CANCRI. 8h. 7m. N.  $17^{\circ} 50'$ . A triple star. Magnitudes 5,  $5\frac{1}{2}$  and  $5\frac{1}{2}$ . Distances  $1''$  and  $5\cdot5''$ :  $4\cdot9''$  (1915).
- α CANIS MAJORIS (*Sirius*). 6h. 42m. S.  $16^{\circ} 35'$ . The brightest fixed star. Its 10th mag. companion is invisible in all but the largest telescopes.
- μ CANIS MAJORIS. 6h. 52m. S.  $13^{\circ} 55'$ . A double star. Magnitudes 4·7 and 8. Distance  $3''$ . Colours, yellow and blue.
- ζ GEMINORUM. 6h. 59m. N.  $20^{\circ} 40'$ . The components of this star are of the 4th and 7th mags. Distance  $94''$ . Two faint *comites* have been seen, one of them with a 3 in. telescope.
- δ GEMINORUM. 7h. 15m. N.  $22^{\circ} 10'$ . A yellowish 3rd mag. star, with an 8th mag. companion,  $7''$  distant.
- α GEMINORUM (*Castor*). 7h. 29m. N.  $32^{\circ} 5'$ . A binary star with a period of about 1000 years. A splendid object in a small telescope. Magnitudes  $2\frac{1}{2}$  and  $3\frac{1}{2}$ . Distance  $6''$ .  $5\cdot2''$  (1914).
- 17 HYDRÆ. 8h. 51m. S.  $7^{\circ} 40'$ . Two almost equal stars of about the 7th mag.,  $4\cdot3''$  apart.
- 12 LYNCS. 6h. 39m. N.  $59^{\circ} 30'$ . A triple star. Magnitudes 5, 6 and  $7\frac{1}{2}$ . Distances  $1\cdot6''$  and  $8\cdot4''$ .
- 8 MONOCEROTIS. 6h. 19m. N.  $4^{\circ} 40'$ . A double star in a grand low-power field. A yellow 4th mag. star, with a bluish *comes* of between the 6th and 7th mag.
- 11 MONOCEROTIS. 6h. 25m. S.  $7^{\circ} 0'$ . A triple star. Magnitudes 5,  $5\frac{1}{2}$  and 6. Distances  $7''$  and  $2\cdot5''$ .

### NEBULÆ & STAR CLUSTERS.

- H. IV. 27. HYDRÆ. 10h. 21m. S.  $18^{\circ} 15'$ . A planetary nebula south of μ. It is of a slightly elliptical shape, resembling Jupiter. It bears magnifying well.
- H. VII. 2. MONOCEROTIS. 6h. 28m. N.  $4^{\circ} 55'$ . A beautiful cluster, the brightest stars being of the 7th and 8th magnitudes. It includes the 6th mag. star 12 Monocerotis.
- M. 50 MONOCEROTIS. 6h. 59m. S.  $8^{\circ} 11'$ . A brilliant cluster.
- M. 44 CANCRI. 8h. 35m. N.  $20^{\circ} 15'$ . *Praesepe*. A naked-eye cluster. A large field and a low power are needed to see it properly. The 'Bee-hive Cluster.'
- M. 67 CANCRI. 8h. 47m. N.  $12^{\circ} 5'$ . A loose cluster of about 200 stars, chiefly of the 9th and 10th magnitudes.
- M. 35 GEMINORUM. 6h. 4m. N.  $24^{\circ} 20'$ . A glorious cluster, visible to the naked eye.

**MAPS 7 AND 8**  
(VI hrs. to X hrs.)



# MAP 7

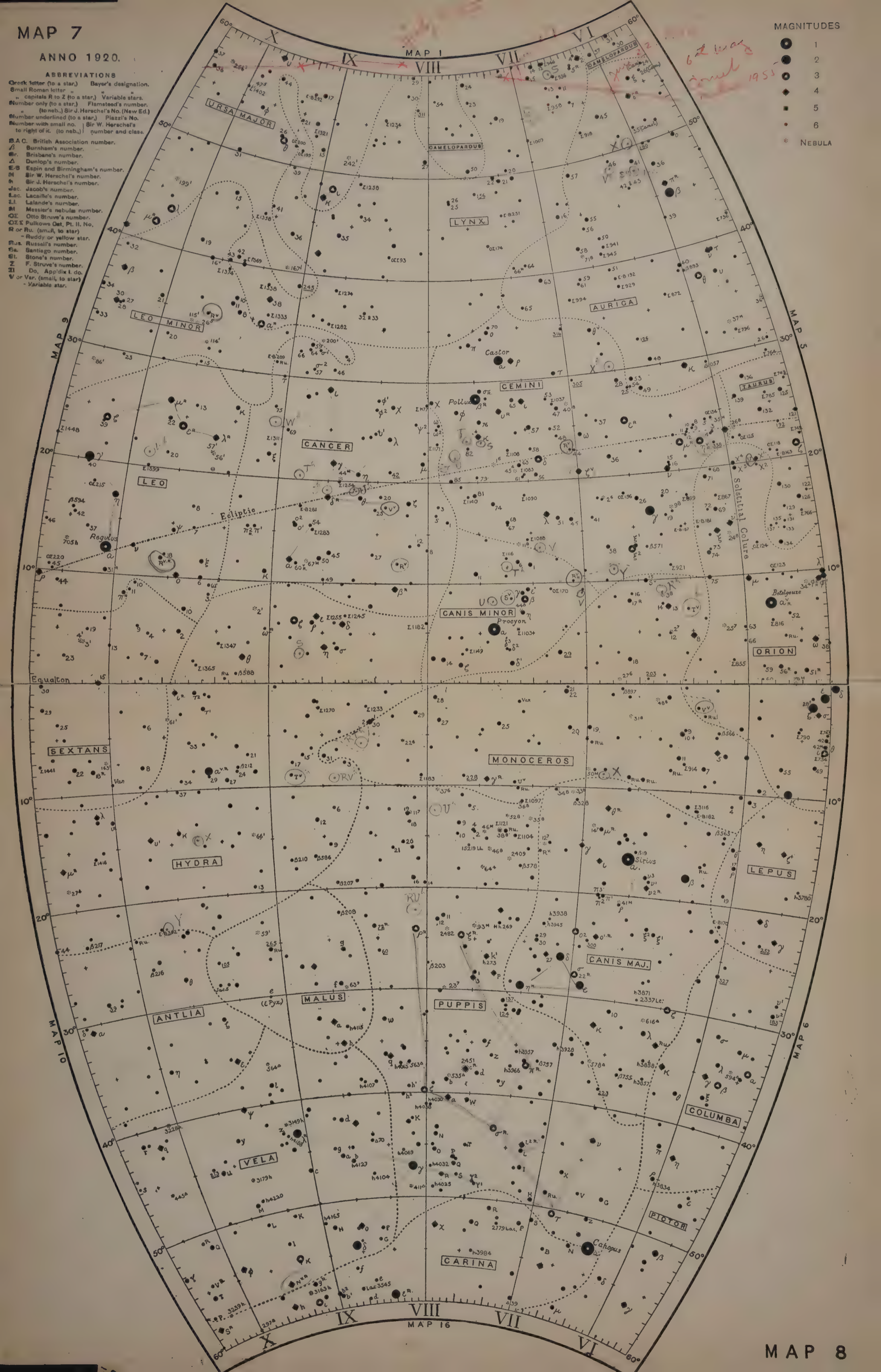
ANNO 1920.

## ABBREVIATIONS

Greek letter (to a star) Bayer's designation.  
 Small Roman letter Variable stars.  
 Capital R to Z (to a star) Flamsteed's number.  
 (to neb.) Sir J. Herschel's No. (New Ed.)  
 Number underlined (to a star) Piazzi's No.  
 Number with small no. Sir W. Herschel's number and class.  
 to right of it. (to neb.)  
 B.A.C. British Association number.  
 B. Burnham's number.  
 Br. Brisbane's number.  
 D. Dunlop's number.  
 E. Espin and Birmingham's number.  
 Sir W. Herschel's number.  
 Sir J. Herschel's number.  
 Jac. Jacob's number.  
 Lac. Lacaille's number.  
 L. Lalonde's number.  
 M. Messier's nebula number.  
 O. Otto Struve's number.  
 O.E.S. Pulaski's Cat. Pt. II. No.  
 R or Ru. (small to star)  
 - Ruddy or yellow star.  
 Ru. Russell's number.  
 Sa. Santiago number.  
 St. Stone's number.  
 F. Struve's number.  
 Do. Appendix I. do.  
 V or Var. (small to star)  
 - Variable star.

## MAGNITUDES

- 1
- 2
- 3
- 4
- 5
- 6
- NEBULA



## TELESCOPIC OBJECTS—MAPS 9 & 10.

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### DOUBLE STARS.

- $\alpha$  (12) CANUM VENATICORUM (*Cor Caroli*). 12h. 52m. N.  $38^{\circ} 45'$ . A double star. Magnitudes 3 and 6. Distance 20".
- 12 COMÆ BERENICES. 12h. 18m. N.  $26^{\circ} 15'$ . A  $4\frac{1}{2}$  mag. star attended by one of  $8\frac{1}{2}$  mag. at a distance of 66".
- $\delta$  CORVI. 12h. 26m. S.  $16^{\circ} 5'$ . A double star. The principal star is of the 3rd mag. and yellow. Magnitude of companion,  $8\frac{1}{2}$ . Distance 24".
- $\Sigma$  1669 CORVI. 12h. 37m. S.  $12^{\circ} 35'$ . A pair of equal  $6\frac{1}{2}$  mag. stars. Distance 5.4".
- $\alpha$  LEONIS (*Regulus*). 10h. 4m. N.  $12^{\circ} 20'$ . Has a companion of the  $8\frac{1}{2}$  mag., distant 177". The *comes* is also a double, but very difficult.
- $\gamma$  LEONIS. 10h. 15m. N.  $20^{\circ} 15'$ . A beautiful object. It consists of a 2nd mag. star with a  $3\frac{1}{2}$  mag. companion 3.6" distant (1907).
- $\epsilon$  LEONIS. 11h. 20m. N.  $11^{\circ} 0'$ . A binary star. Magnitudes 4 and 7. Distance 2.4" (1906). 2" (1914).
- $\xi$  URSÆ MAJORIS. 11h. 14m. N.  $32^{\circ} 0'$ . A fine binary star, with a period of about 61 years. The magnitudes of its components are 4 and 5, their distance 2.5" (1907). 3" (1913). Now closing (1918).
- $\gamma$  VIRGINIS. 12h. 37m. S.  $1^{\circ} 0'$ . A very fine binary star, with a period of about 180 years. In 1780 the distance of the components was 6". In 1836 they could only be seen as an elongated star. Since then they have gradually widened to 5.6" (1891): 6" (1914). The stars are both of the 3rd magnitude.
- $\theta$  VIRGINIS. 13h. 6m. S.  $5^{\circ} 5'$ . A 4th mag. star with a 9th mag. *comes*, 7" distant. A severe test for a 3 in. telescope, though Ward glimpsed it with  $2\frac{1}{4}$  in. in 1875.

### VARIABLE STARS.

- $\eta$  ARGÛS. 10h. 42m. S.  $59^{\circ} 15'$ . A most remarkable variable star, in a wonderful nebula. In 1677 it was 4th mag., rose to 2nd mag. in 1751, then sank to 4th mag. In 1827 it rose to 1st mag. and for about five years was 2nd mag. In 1837 it returned to 1st mag., faded slightly, and then in 1843 became almost as bright as Sirius. In 1862 it became invisible to the naked eye. It was 7th mag. in 1892 and  $7\frac{1}{2}$  mag. in 1902. 7.8 mag. (1914).

### NEBULÆ & STAR CLUSTERS.

- M. 51 CANUM VENATICORUM. 13h. 26m. N.  $47^{\circ} 35'$ . A spiral nebula; but small telescopes will not show its formation.
- M. 3 CANUM VENATICORUM. 13h. 38m. N.  $28^{\circ} 45'$ . A beautiful globular cluster, but hardly resolvable into stars with a small telescope.
- 5139,  $\omega$  CENTAURI. 13h. 22m., S.  $46^{\circ} 55'$ . A great and glorious globular cluster containing thousands of stars of 12th to 15th magnitude.

**MAPS 9 AND 10**

*(X hrs. to XIV hrs )*



MAP 9

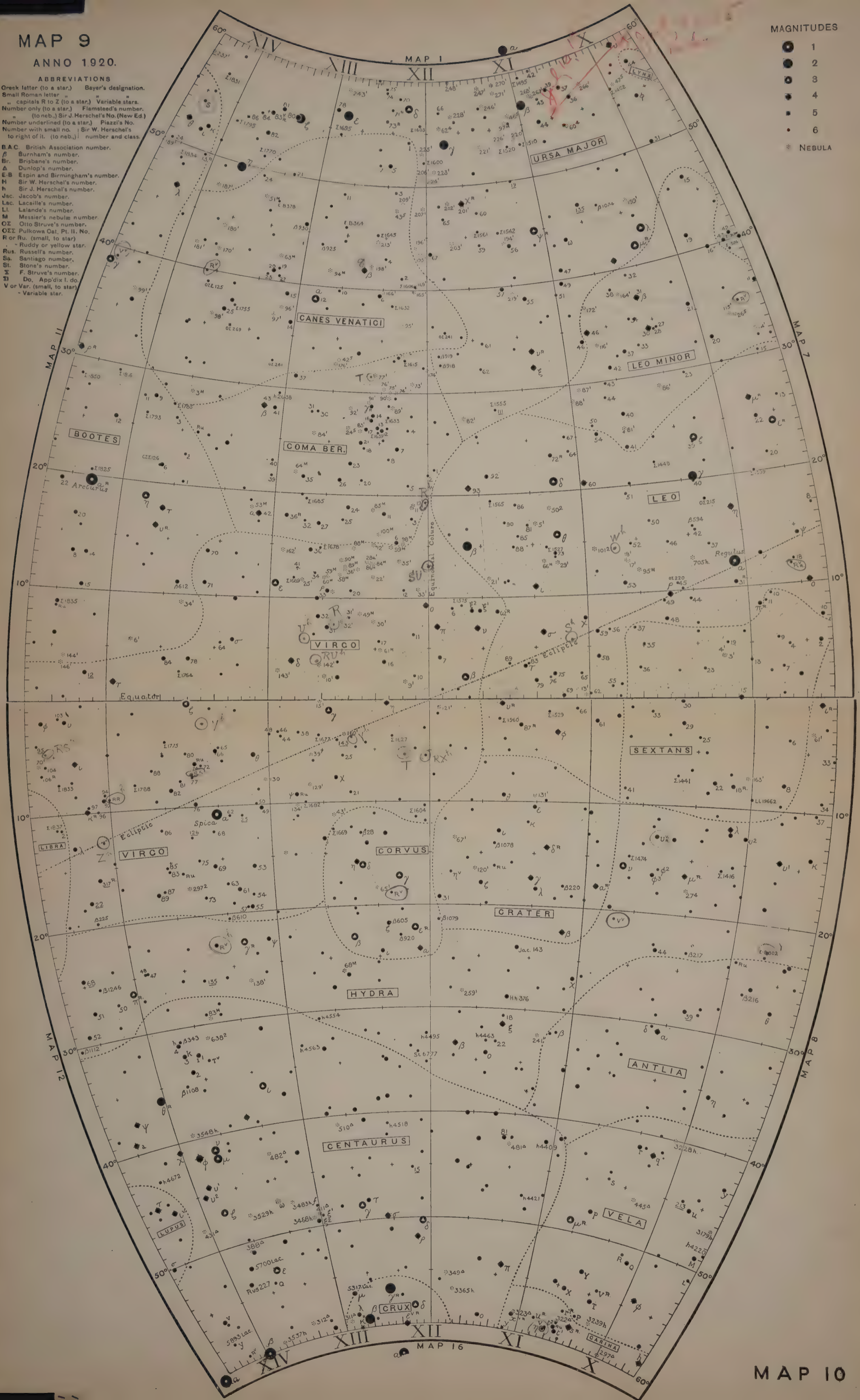
ANNO 1920.

ABBREVIATIONS

Greek letter (to a star) Bayer's designation.  
Small Roman letter " capitals R to Z (to a star) Variable stars.  
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(to neb.) Sir J. Herschel's No. (New Ed.)  
Number underlined (to a star) Piazzi's No.  
Number with small no. Sir W. Herschel's  
to right of it. (to neb.) number and class.  
B.A.C. British Association number.  
β Burnham's number.  
Br. Brisbane's number.  
Δ Dunlop's number.  
E.B. Espin and Birmingham's number.  
H Sir W. Herschel's number.  
h Sir J. Herschel's number.  
Jac. Jacob's number.  
Lac. Lacaille's number.  
L.I. Lalande's number.  
M Messier's nebula number.  
OZ Otto Struve's number.  
OZZ Pulkowa Cat. Pt. II. No.  
R or Ru. (small, to star) Ruddy or yellow star.  
Rus. Russell's number.  
Sa. Santiago number.  
St. Stone's number.  
Σ F. Struve's number.  
Do. Appendix I. do.  
V or Var. (small, to star) Variable star.

MAGNITUDES

- 1
- 2
- 3
- 4
- 5
- 6
- NEBULA



# TELESCOPIC OBJECTS—MAPS 11 & 12.

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## DOUBLE STARS.

- $\kappa$  BOÖTIS. 14h. 11m. N.  $52^{\circ} 10'$ . One of three stars near the end of the Great Bear's tail. A 5th mag. star with a 7th mag. attendant. Distance  $12.6''$ .
- $\pi$  BOÖTIS. 14h. 37m. N.  $16^{\circ} 45'$ . A double star. Magnitudes 5 and 6. Distance  $7''$ .
- $\epsilon$  BOÖTIS (*Pulcherrima*). 14h. 42m. N.  $27^{\circ} 15'$ . A beautiful double star, consisting of a 3rd mag. yellow, and a  $6\frac{1}{2}$  mag. blue star, at  $2.6''$  distance:  $2.9''$  (1915). A most lovely object and a test for small instruments: well seen in  $2\frac{1}{2}$ -inch achromatic.
- $\xi$  BOÖTIS. 14h. 48m. N.  $19^{\circ} 25'$ . A binary star. The magnitudes of its components are 4.7 and 6.6. Distance  $3.2''$  (1891).  $2.2''$  (1914). The period is probably about 130 years.
- $\zeta$  CORONÆ BOREALIS. 15h. 36m. N.  $36^{\circ} 55'$ . A white 4th mag. star with a greenish 6th mag. companion  $6''$  distant.
- $\alpha$  HERCULIS. 17h. 11m. N.  $14^{\circ} 30'$ . One of the first doubles in the heavens. A 3rd mag. variable orange star with a blue or green attendant of the 6th mag., distant  $4.6''$ .
- 36 OPHIUCHI. 17h. 10m. S.  $26^{\circ} 30'$ . A binary star. Two 6th mag. stars,  $4.3''$  apart (1888).
- 39 OPHIUCHI. 17h. 13m. S.  $24^{\circ} 10'$ . A beautiful double star. A  $5\frac{1}{2}$  mag. orange star with a 6 mag. blue companion at  $15''$  distance.
- $\xi$  SCORPIONIS. 16h. 0m. S.  $11^{\circ} 10'$ . A triple star. The magnitudes of the components are 5, 5, and 7. Their distances in 1888 were  $1''$  and  $7''$ . In 1907 the nearer pair had closed up to  $0.2''$ . Now opening;  $0.7''$  (1912).
- $\beta$  SCORPIONIS. 16h. 1m. S.  $19^{\circ} 35'$ . A double star. The magnitudes are 2 and 4, and their distance  $13''$ .
- $\alpha$  SCORPIONIS (*Antares*). 16h. 24m. S.  $26^{\circ} 15'$ . A fiery red star of the first magnitude. It has a 7th mag. green companion  $3''$  distant; but this can rarely be seen in small telescopes, owing to the overpowering glare of the large star.
- $\delta$  SERPENTIS. 15h. 31m. N.  $10^{\circ} 50'$ . A binary system. The components are of the 3rd and 4th mags. Distance  $3.6''$  (1889).

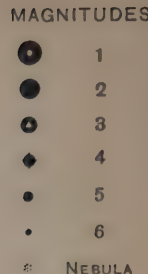
## VARIABLE STARS & STAR CLUSTERS.

- T CORONÆ BOREALIS. 15h. 56m. N.  $26^{\circ} 10'$ . The "Blaze Star" flamed up to 2nd mag. in 1866, and has since decreased irregularly. 9th mag. in 1892. 9.4 mag. (1907).
- M. 13 HERCULIS. 16h. 39m. N.  $36^{\circ} 35'$ . A grand cluster between  $\eta$  and  $\zeta$ , and nearer the former. It is visible to the naked eye.
- M. 19 OPHIUCHI. 16h. 57m. S.  $26^{\circ} 10'$ . A bright cluster, but low for observation in the latitude of the British Isles.
- M. 9 OPHIUCHI. 17h. 14m. S.  $18^{\circ} 25'$ . A small but brilliant cluster.
- M. 23 OPHIUCHI. 17h. 52m. S.  $19^{\circ} 0'$ . A splendid field with a low power.

**MAPS 11 AND 12**  
(XIV hrs. to XVIII hrs.)



B.A.C. British Association number.  
 $\beta$  Burnham's number.  
 Br. Brisbane's number.  
 $\Delta$  Dunlop's number.  
 E-B Espin and Birmingham's number.  
 H Sir W. Herschel's number.  
 h Sir J. Herschel's number.  
 Jac. Jacob's number.  
 Lac. Lacaille's number.  
 L.I. Laflamme's number.  
 M. Messier's nebula number.  
 OX Otto Struve's number.  
 OK Pulkova Cat. Pl. II. No.  
 R or Ru. (small, to star)  
     - Ruddy or yellow star.  
 Rus. Russell's number.  
 Sa. Santiago number.  
 St. Stone's number.  
 S. F. Struve's number.  
 T. Appendix I do.  
 U or Var. (small, to star)  
     = Variable star.



## TELESCOPIC OBJECTS—MAPS 13 & 14.

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### DOUBLE STARS.

- ζ AQUARI. 22h. 25m. S. 0° 25'. A beautiful object. Two 4th mag. stars at a distance of 3" (1892).
- 15 AQUILÆ. 19h. 1m. S. 4° 10'. A double star. The components are of 6 and 7½ mags., and their colours yellow and ruddy. Distance 34". About 1° N. of λ and slightly preceding it.
- π AQUILÆ. 19h. 45m. N. 11° 35'. A double star with components of the 6th and 7th mags. Distance 1.4". A test object for a 3 in. telescope.
- α CAPRICORNI. 20h. 13m. S. 12° 45'. A grand naked-eye pair. The stars are of the 3rd and 4th magnitudes and 6' 16" apart.
- β CYGNI. 19h. 27m. N. 27° 45'. A magnificent double star. A 3rd mag. golden-yellow star with a blue attendant of 5½ mag. Distance 34".
- 61 CYGNI. 21h. 3m. N. 38° 20'. The first star to have its distance measured, by Bessel. A double star. Magnitudes 5½ and 6, nearly equal. Distance 21". 23.5" (1913).
- μ CYGNI. 21h. 40m. N. 28° 25'. A double star. Magnitudes 4 and 5. Distance 5.6". 1.7" (1914).
- γ DELPHINI. 20h. 43m. N. 15° 50'. A beautiful and easy double star. The magnitudes are 4 and 5, and their distance 11".
- α LYRÆ (*Vega*). 18h. 34m. N. 38° 40'. Is considered by some to be the second brightest fixed star. It has a 10th mag. attendant 52" off, which has been seen on rare occasions with smaller apertures, but is a hard test for a 3 in. telescope. There are several distant small stars in the field.
- ε¹ and ε² LYRÆ. 18h. 42m. N. 39° 30'. The "Double-double." The two stars have been seen by the naked eye by several observers: to most they appear elongated. ε¹ has components of mags. 4½ and 6½ at 3" distance; ε² of 5 and 5.2 mag. at 2.3" distance. Between the pairs are 3 other stars, one of them very faint.

### NEBULÆ & STAR CLUSTERS.

- M. 2 AQUARI. 21h. 29m. S. 1° 10'. A magnificent globular cluster of 5' or 6' diameter.
- M. 11 AQUILÆ. 18h. 46m. S. 6° 20'. A grand cluster, just visible to the naked eye.
- M. 57 LYRÆ. 18h. 51m. N. 32° 55'. The "Ring Nebula," between β and γ. Its form may be seen in a 2½ in. telescope. It bears magnifying well.
- M. 20 SAGITTARI. 17h. 57m. S. 23° 0'. The "Trifid Nebula." In large telescopes, three dark rifts are seen to meet in the middle of the nebula.
- M. 8 SAGITTARI. 17h. 59m. S. 24° 20'. A splendid cluster. Fine low-power field.
- M. 27 VULPECULÆ. 19h. 56'. N. 22° 30'. The "Dumb-bell Nebula," so called from its appearance in moderate-sized telescopes.

### VARIABLE STAR.

- Nova AQUILÆ 3 (1918). R.A. 18h. 45m., Dec. 0° 29'N. At its brightest it was about Mag. 0.1.

**MAPS 13 AND 14**  
(XVIII hrs. to XXII hrs.)



MAP 13

ANNO 1920.

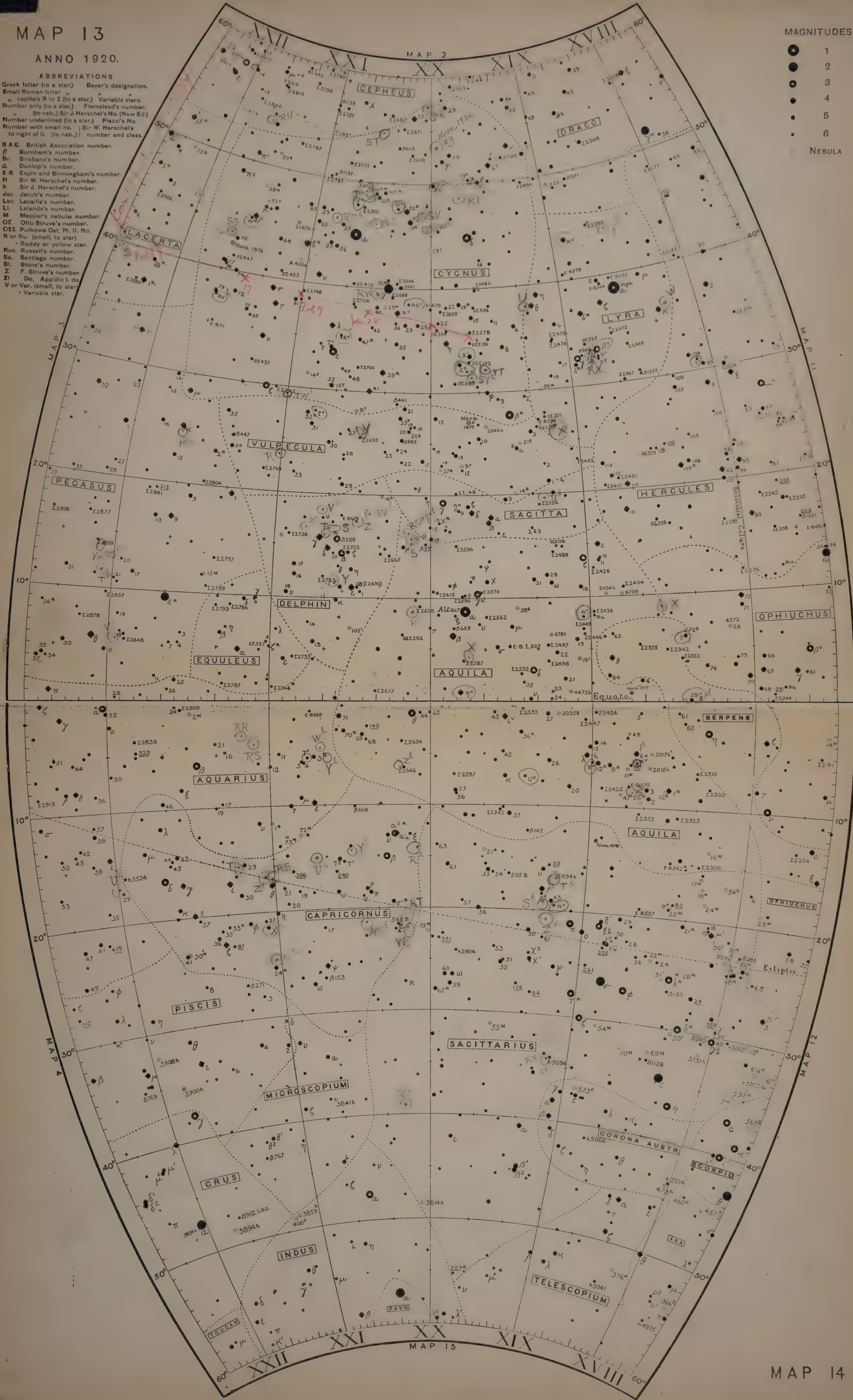
ABBREVIATIONS

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(to a star.) Sir J. Herschel's No. (New Ed.)  
Number underlined (to a star.) Piazzi's No.  
Number with small no. (to a star.) Sir W. Herschel's  
to right of it. (to neb.) number and class.  
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Br. Brisbane's number.  
D. Dunlop's number.  
E.B. Ekin and Birmingham's number.  
H. Sir W. Herschel's number.  
h. Sir J. Herschel's number.  
Jac. Jacob's number.  
Lac. Lacaille's number.  
L.I. Lalande's number.  
M. Messier's nebula number.  
OZ. Otto Struve's number.  
O.I. Pulkova Cat. Pl. II. No.  
R or Ru. (small, to star)  
- Ruddy or yellow star.  
Rus. Russell's number.  
Sa. Santiago number.  
St. Stone's number.  
Z. F. Struve's number.  
Z. Appendix I. do  
V or Var. (small, to star)  
- Variable star.

MAGNITUDES

- 1
- 2
- 3
- 4
- 5
- 6

NEBULA



## TELESCOPIC OBJECTS—MAPS 15 & 16.



### DOUBLE STARS.

- $\alpha$  CENTAURI. 14h. 34m. S.  $60^{\circ} 30'$ . The nearest fixed star. A remarkable binary star, with a period of 81 years. The finest in the heavens. It is composed of two yellow stars, 1st and 2nd magnitudes, distant  $16\cdot5''$  in 1836,  $7\cdot6''$  in 1851,  $18\cdot6''$  in 1890,  $21\cdot6''$  in 1902.  $15\cdot5''$  (1917).
- $\alpha$  CRUCIS. 12h. 22m. S.  $62^{\circ} 40'$ . This magnificent object consists of two 2nd mag. stars, nearly  $5''$  apart, with a 6th mag. star at a distance of  $90''$ .
- $\gamma$  CRUCIS. 12h. 26m. S.  $56^{\circ} 40'$ . A second mag. star with a 5th mag. *comes* at  $101''$  distance. The brighter star, of an orange-yellow colour, is probably variable.
- $\mu$  CRUCIS. 12h. 50m. S.  $56^{\circ} 45'$ . A double star. The components are of the 5th and 6th magnitudes. Distance  $34''$ .
- 6 (p) ERIDANI. 1h. 37m. S.  $56^{\circ} 35'$ . Two 6th mag. stars  $3\cdot6''$  apart in 1835,  $7''$  in 1890,  $8\cdot3''$  (1911): a binary system.
- 9367 Lac. GRUIS. 23h. 3m. S.  $51^{\circ} 5'$ . A double star. Magnitudes  $6\frac{1}{2}$  and 7. Distance  $8''$ .
- $\lambda$  OCTANTIS. 21h. 39m. S.  $83^{\circ} 5'$ . A double star. Magnitudes 6 and 9. Distance  $3\cdot4''$ .
- $\epsilon$  PICTORIS. 4h. 49m. S.  $53^{\circ} 35'$ . A double star. Magnitudes  $5\frac{1}{2}$  and  $6\frac{1}{2}$ . Distance  $12''$ .
- $\gamma$  PISCIS VOLANTIS. 7h. 9m. S.  $70^{\circ} 25'$ . A double star. The components are of the  $4\frac{1}{2}$  and 7th mags. Distance  $13''$ .

### NEBULÆ & STAR CLUSTERS.

- 30 DORADÛS. 5h. 39m. S.  $69^{\circ} 10'$ . A large, bright nebula "in the form of a loop."
- 265  $\Delta$  CARINÆ. 9h. 10m. S.  $64^{\circ} 30'$ . A large, rich, globular cluster.
- $\kappa$  CRUCIS. 12h. 49m. S.  $59^{\circ} 55'$ . Is surrounded by a bright and beautiful cluster of stars of various colours.
- 47 TOUCANI. 0h. 20m. S.  $72^{\circ} 30'$ . A grand globular cluster, containing about 1500 stars of the 12th to 14th magnitude. Visible to the naked eye as a hazy  $4\frac{1}{2}$  mag. star. "A superb object" (Sir J. Herschel).

**MAPS 15 AND 16**  
*(Circumpolar, South)*



# MAP 15

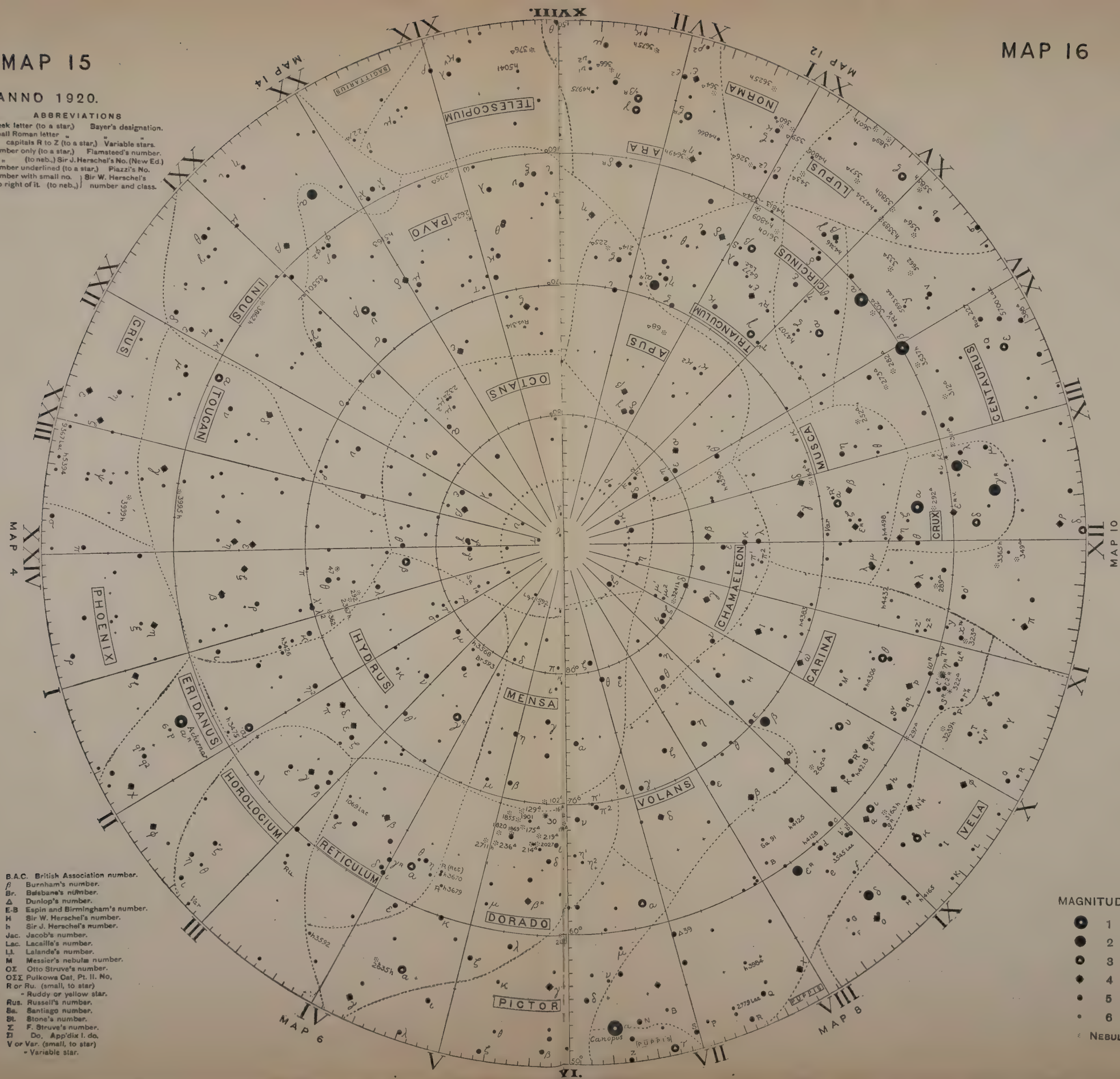
ANNO 1920.

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Δ Dunlop's number.  
E.B. Espin and Birmingham's number.  
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h Sir J. Herschel's number.  
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L.L. Lalande's number.  
M. Messier's nebula number.  
O.S. Otto Struve's number.  
O.S. Pulkova Cat. Pt. II. No.  
R or Ru. (small, to star)  
- Ruddy or yellow star.  
Rus. Russell's number.  
Sa. Santiago number.  
St. Stone's number.  
Σ F. Struve's number.  
D. Do. App'dix I. do.  
V or Var. (small, to star)  
- Variable star.

# MAP 16



# INDEX TO THE CONSTELLATIONS.

*With the number of the Map in which each is shown, and the approximate date of culmination of its central hour of Right Ascension at 9 p.m. and Midnight.*

For each Hour later or earlier than 9 a.m. or midnight—

*Earlier*—Add 15 days to dates given below.

*Later*—Subtract 15 days from „ „ „

For each Week later or earlier than dates below—

*Earlier*—Add 28 minutes to 9 p.m. or midnight.

*Later*—Subtract „ „ from „ „ „

Name of Constellation	Genitive.	See Map No.	Approx. Date Culmination 9 p.m.	Approx. Date Culmination Midnight.	Name of Constellation.	Genitive.	See Map No.	Approx. Date Culmination 9 p.m.	Approx. Date Culmination Midnight.
ANDROMEDA	Andromedæ	3	Nov. 15	Oct. 1	INDUS† ...	Indi	14, 15	Sept. 26	Aug. 12
ANTLIA† ...	... Antliæ	8	Apr. 10	Feb. 24	LACERTA† ...	Lacertæ	3	Oct. 14	Aug. 30
APUS† ...	... Apodis	16	June 30	May 16	LEO ...	Leonis	9	Apr. 15	Mar. 1
AQUARIUS	... Aquarii	4	Oct. 7	Aug. 23	LEO MINOR†	Leonis Minoris	9	Apr. 12	Feb. 26
AQUILA ...	... Aquilæ	13	Aug. 30	July 16	LEPUS ...	Leporis	6	Jan. 29	Dec. 15
ARA ...	... Aræ	12	July 22	June 7	LIBRA ...	Libræ	12	June 25	May 11
ARGO ...	... Argûs	8	Mar. 11	Jan. 25	LUPUS ...	Lupi	12	June 19	May 5
ARIES ...	... Arietis	5	Dec. 12	Oct. 28	LYNX† ...	Lyncis	1, 7	Mar. 5	Jan. 19
AURIGA ...	... Aurigæ	5	Feb. 2	Dec. 19	LYRA ...	Lyræ	13	Aug. 18	July 4
BOÛTES ...	... Boötis	11	June 12	Apr. 28	MALUS† (ARGO) ...	Mali	8	Mar. 19	Feb. 2
CAELUM† ...	... Cæli	6	Jan. 13	Nov. 29	MENSA† ...	Mensæ	15, 16	Feb. 3	Dec. 20
CAMELOPARDUS†	Camelopardi	1, 2	Jan. 31	Dec. 17	MICROSCOPIUM†	Microscopii	14	Sept. 19	Aug. 5
CANCER ...	Cancri	7	Mar. 12	Jan. 26	MONOCEROS†	Monocerotis	7, 8	Feb. 22	Jan. 8
CANES VENATICI†	Canum Venaticorum	9	May 21	Apr. 6	MUSCA† ...	Muscæ	16	May 14	Mar. 30
CANIS MAJOR	Canis Majoris	8	Feb. 13	Dec. 30	NORMA† ...	Normæ	12	July 6	May 22
CANIS MINOR	Canis Minoris	7	Feb. 27	Jan. 13	OCTANS† ...	Octantis	15, 16	Circumpolar	
CAPRICORNUS	Capricorni	14	Sept. 19	Aug. 5	OPHIUCHUS	Ophiuchi	11, 12	July 25	June 10
CARINA† (ARGO) ...	Carinæ	8, 16	Mar. 16	Jan. 30	ORION ...	Orionis	5, 6	Jan. 23	Dec. 9
CASSIOPEIA	Cassiopeïæ	2, 3	Nov. 20	Oct. 6	PAVO† ...	Pavonis	15	Aug. 24	July 10
CENTAURUS	Centauri	10	May 25	Apr. 10	PEGASUS ...	Pegasi	3	Oct. 15	Aug. 31
CEPHEUS ...	Cephei	2	Oct. 10	Aug. 26	PERSEUS ...	Persei	5	Dec. 21	Nov. 6
CETUS ...	Ceti	4, 5	Nov. 30	Oct. 16	PHOENIX†	Phœnicis	4	Nov. 9	Sept. 25
CHAMAELEON†	Chamæleontis	16	Apr. 13	Feb. 27	PICTOR† ...	Pictoris	6	Jan. 29	Dec. 15
CIRCINUS†	Circini	12, 16	June 24	May 10	PISCES ...	Piscium	3	Nov. 12	Sept. 28
COELUM† (CAELUM)	Cæli	6	Jan. 13	Nov. 29	PISCIS AUSTRALIS	Piscis Australis	4	Sept. 30	Aug. 16
COLUMBA†	Columbæ	6	Jan. 31	Dec. 17	PUPPIS† (ARGO) ...	Puppis	8	Feb. 26	Jan. 12
COMA BERENICES†	Comæ Berenices	9	May 17	Apr. 2	RETICULUM†	Reticuli	15	Jan. 4	Nov. 20
COROLLA (Corona Australis)	Corollæ	14	Aug. 12	June 28	SAGITTA ...	Sagittæ	13	Aug. 31	July 17
CORONA AUSTRALIS	Coronæ Australis				SAGITTARIUS	Sagittarii	14	Aug. 20	July 6
CORONA BOREALIS	Coronæ Borealis	11	July 2	May 18	SCORPIO ...	Scorpii	12	July 10	May 26
CORVUS ...	Corvi	10	May 13	Mar. 29	SCULPTOR†	Sculptoris	4	Nov. 14	Sept. 30
CRATER ...	Crateris	10	Apr. 28	Mar. 14	(SCUTUM†)*	Scuti	13	Aug. 12	June 28
CRUX† ...	Crucis	16	May 14	Mar. 30	SERPENS ...	Serpentis	11	July 21	June 6
CYGNUS ...	Cygni	13	Sept. 10	July 27	SEXTANS† ...	Sextantis	9, 10	Apr. 9	Feb. 23
DELPHINUS	Delphini	13	Sept. 15	Ang. 1	TAURUS ...	Tauri	5	Jan. 15	Dec. 1
DORADO† ...	Doradûs	15, 16	Jan. 17	Dec. 3	(TAURUS PONIATOWSKII)†		13	Aug. 9	June 25
DRACO ...	Draconis	1, 2	July 10	May 26	TELESCOPIUM†	Telescopii	14	Aug. 14	June 30
EQUULEUS	Equulei	13	Sept. 21	Aug. 7	TOUCAN†	Toucanis	15	Oct. 30	Sept. 15
ERIDANUS ...	Eridani	6	Jan. 2	Nov. 18	TRIANGULUM {	Trianguli	16	July 4	May 20
FORNAX† ...	Fornacis	6	Dec. 12	Oct. 28	AUSTRALE† }	Australis			
GEMINI ...	Geminorum	7	Feb. 20	Jan. 6	TRIANGULUM	Trianguli	3	Dec. 5	Oct. 21
GRUS† ...	Gruis	4	Oct. 9	Aug. 25	URSA MAJOR	Ursæ Majoris	1, 9	Apr. 21	Mar. 7
HERCULES	Herculis	11	July 21	June 6	URSA MINOR	Ursæ Minoris	1	June 25	May 11
HOROLOGIUM†	Horologii	6, 15	Dec. 20	Nov. 5	VELA† (ARGO) ...	Velorum	8	Mar. 29	Feb. 12
HYDRA ...	Hydræ	7, 10	Apr. 30	Mar. 16	VIRGO ...	Virginis	9, 10	May 25	Apr. 10
HYDRUS† ...	Hydri	15	Dec. 14	Oct. 30	VOLANS† ...	Volantis	16	Mar. 1	Jan. 15
					VULPECULA†	Vulpeculæ	13	Sept. 8	July 25

\* This constellation (Scutum Sobieskii) is occasionally used, especially in America, to denote the lower corner of Aquila adjoining the tail of Serpens. It extends from about R.A. 18h. to 18h. 56m., and from Dec. 2° S. to 16° S.  $\alpha=1$  Aquilæ;  $\beta=6$  Aquilæ;  $\gamma=B.A.C. 6279$ ;  $\delta=2$  Aquilæ;  $\epsilon=3$  Aquilæ;  $\eta=9$  Aquilæ. † TAURUS PONIATOWSKII is another small modern asterism. It is situated in the region bordering Hercules, between Aquila and Ophiuchus, where some stars form the letter V. ‡ Constellations so marked are modern.



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P. ...  
M. ...  
Y. ...

# SOUTHERN INDEX MAP



